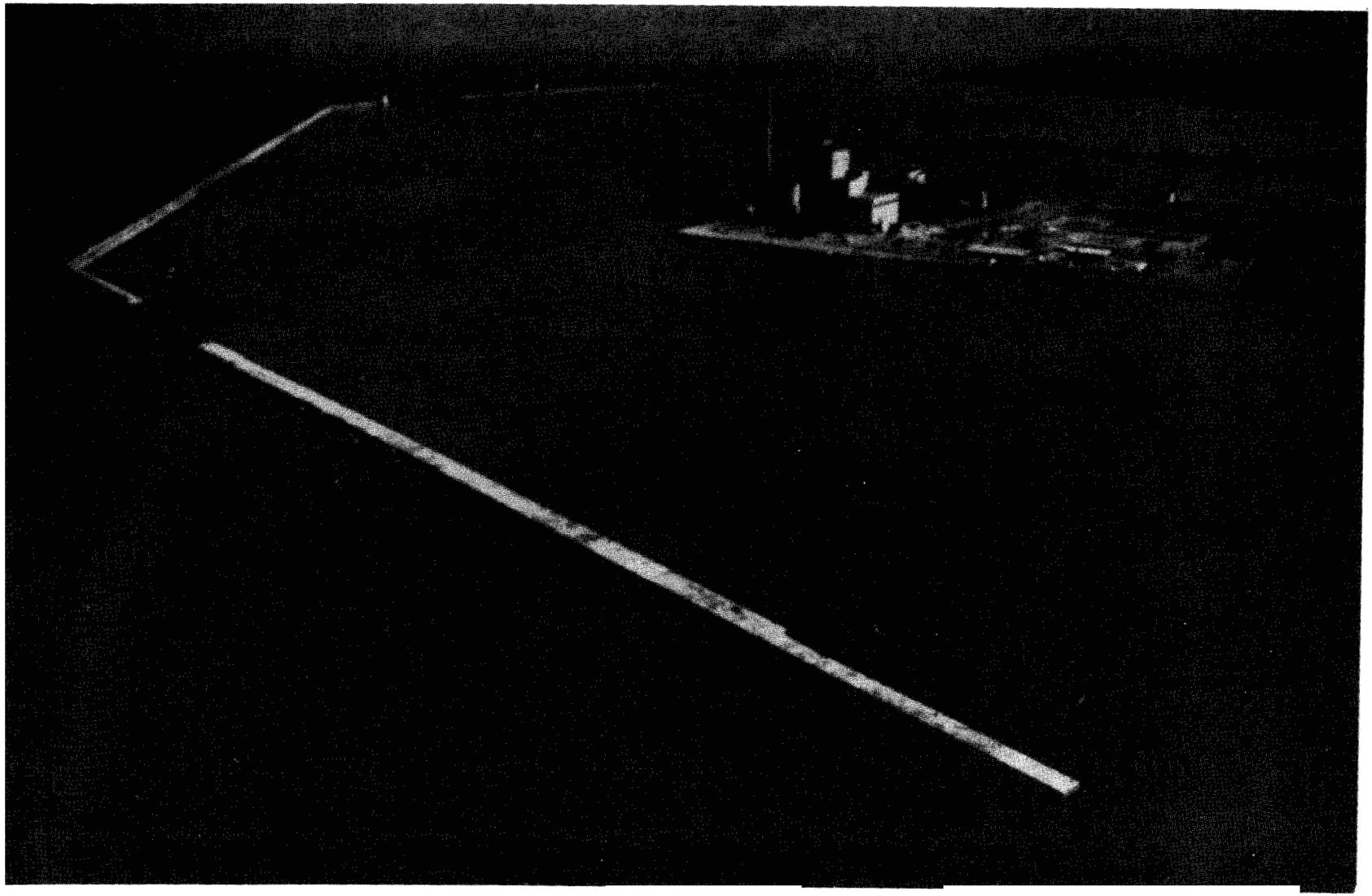


Figure 194. Aerial view of Harbor Beach, Michigan

Table 73

Port Sanilac Harbor Breakwaters

Port Sanilac, Michigan

Date(s)	Construction and Rehabilitation History
1951	Construction of a 1,230-ft-long north breakwater and a 949-ft-long south breakwater (Figure 195, Types A, B, C, and D) was completed. The shoreward ends of both structures consisted of steel sheetpiling with an el of +8.0 ft lwd (Figure 196, Type D). Riprap was placed on the lakesides of the structures. The remaining portions of the breakwaters were constructed of sand- and gravel-filled cellular steel sheet-pile structures with cell diameters ranging from 23.87 (Figure 196, Type A) to 28.85 ft (Figure 196, Types B and C). The Type C structure at the lakeward end of the north breakwater (Figure 196) had a crest el of +10 ft lwd, and the remaining portions (Types A and B) were installed at a +8 ft lwd crest el. Riprap was placed on both sides of the lakeward portion of the north breakwater (Type C) and on only the lakesides of the cells of the remaining structures (Types A and B). The cells were capped with asphalt.
1975	To reduce wave heights in the harbor to approximately one-half foot, a 327-ft-long extension to the north breakwater and a 69-ft-long extension of the south breakwater (Figure 195, Types E and F) was completed. The north breakwater extension consisted of stone-filled, steel sheet-pile cells with a diameter of 43 ft and a crest el of +10 ft lwd (Figure 196, Type E). The south breakwater extension was constructed of stone-filled cellular sheet piles (Figure 196, Type F) with diameters of 31.8 ft and a crest el of +8 ft lwd. The extensions were capped with bituminous concrete. Riprap stone ranging from 1,000 lb to 1 ton was placed on both sides of the north breakwater extension and on the lakeside of the south extension.
1984	A site inspection of the structures revealed that some of the asphalt caps of the north breakwater had settled, but the breakwaters were generally in good condition. An aerial view of the Port Sanilac Harbor breakwaters is shown in Figure 197.

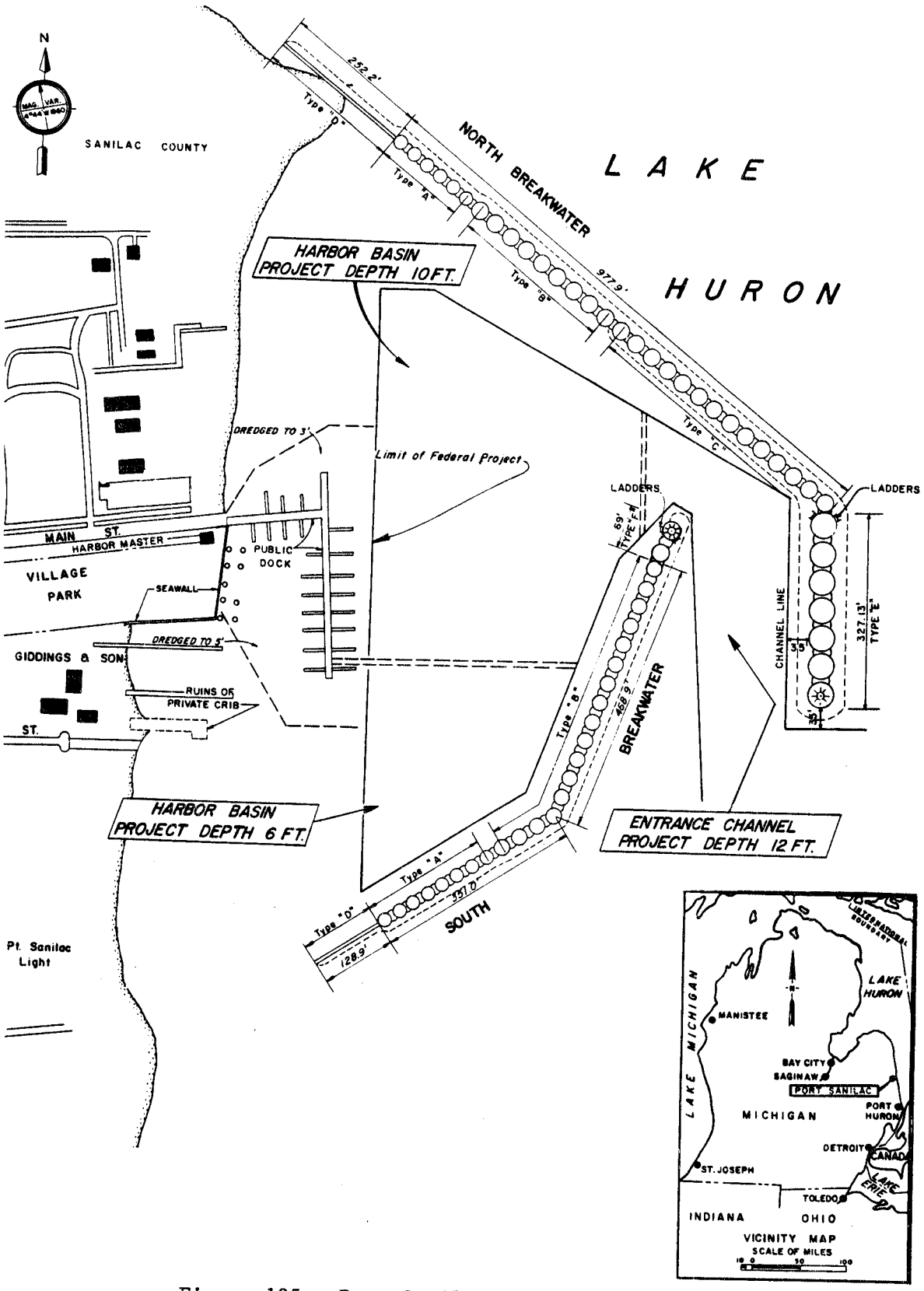


Figure 195. Port Sanilac Harbor, Michigan

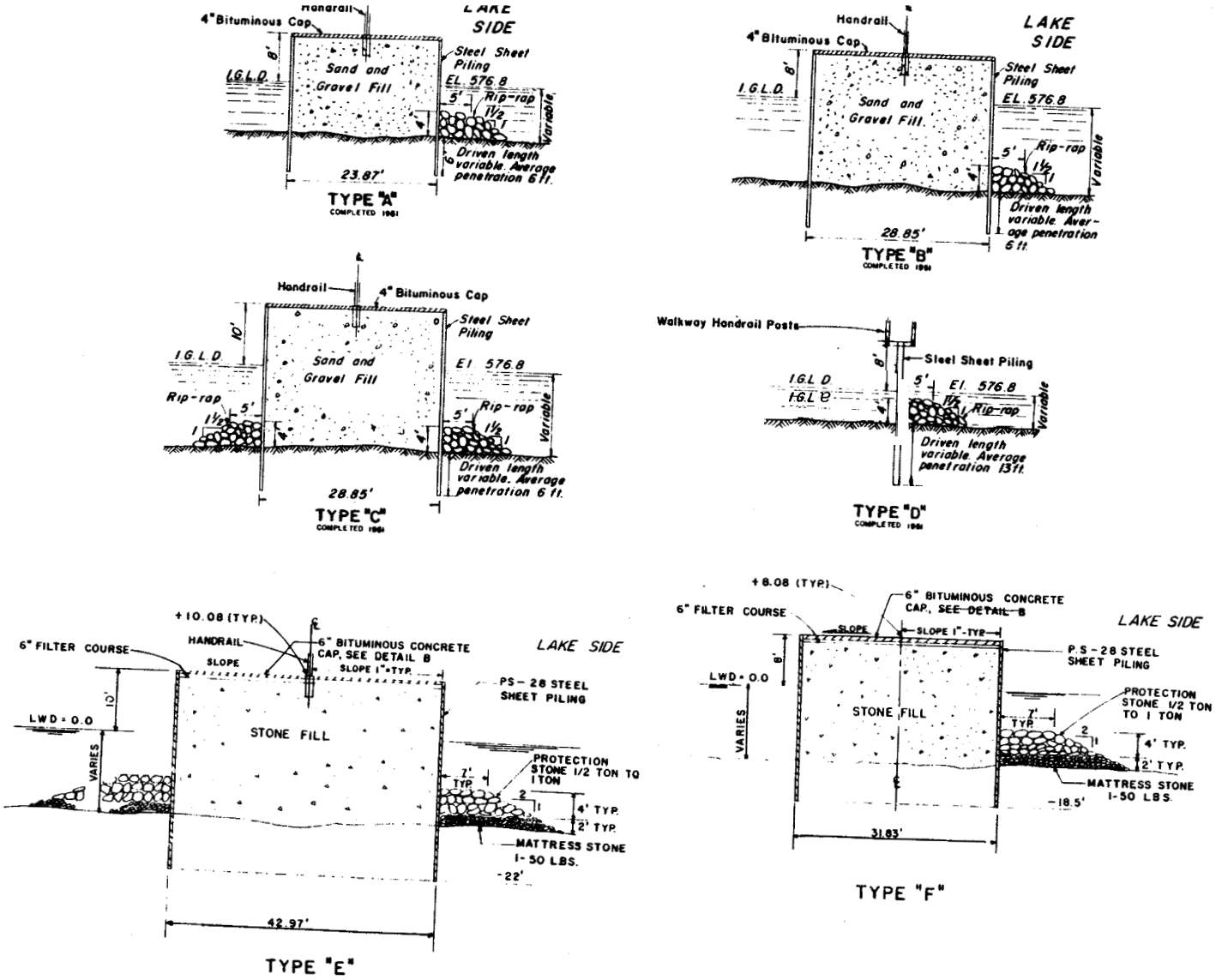


Figure 196. Typical structure cross sections, Port Sanilac Harbor, Michigan

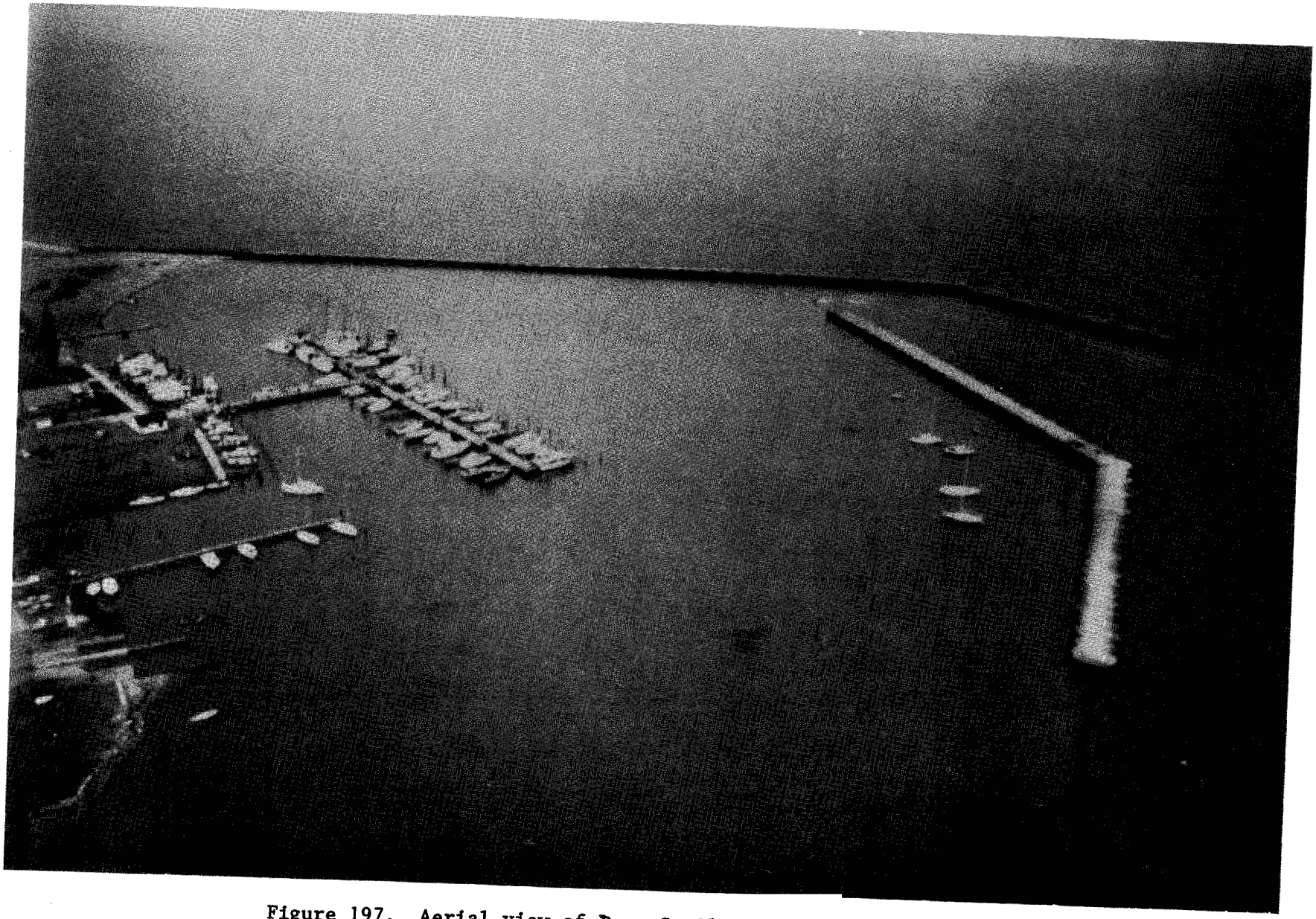


Figure 197. Aerial view of Port Sanilac Harbor Michigan

Table 74

Lexington Harbor Breakwaters

Lexington, Michigan

Date(s)	Construction and Rehabilitation History
1976	Construction of a 1,905-ft-long north breakwater and a 690-ft-long south breakwater (Figure 198) was completed. The north breakwater was a rubble-mound structure with a 15-ft-wide crest and 1-V:1.5-H side slopes. The crest el was +9.5 ft lwd for the shoreward 300-ft length and +11.5 ft lwd for the remaining portions of the structure (Figure 199). Cover stone ranging from 4.5 to 16 tons was used. The south breakwater was a rubble-mound structure also with a crest el of +8 ft lwd and a crest width of 8 ft (Figure 199). Side slopes of 1V:1.5H and cover stone ranging from 350 to 850 lb were utilized.
1984	A site inspection of the breakwaters indicated that they were in very good condition. An aerial view of the Lexington Harbor breakwaters is shown in Figure 200.

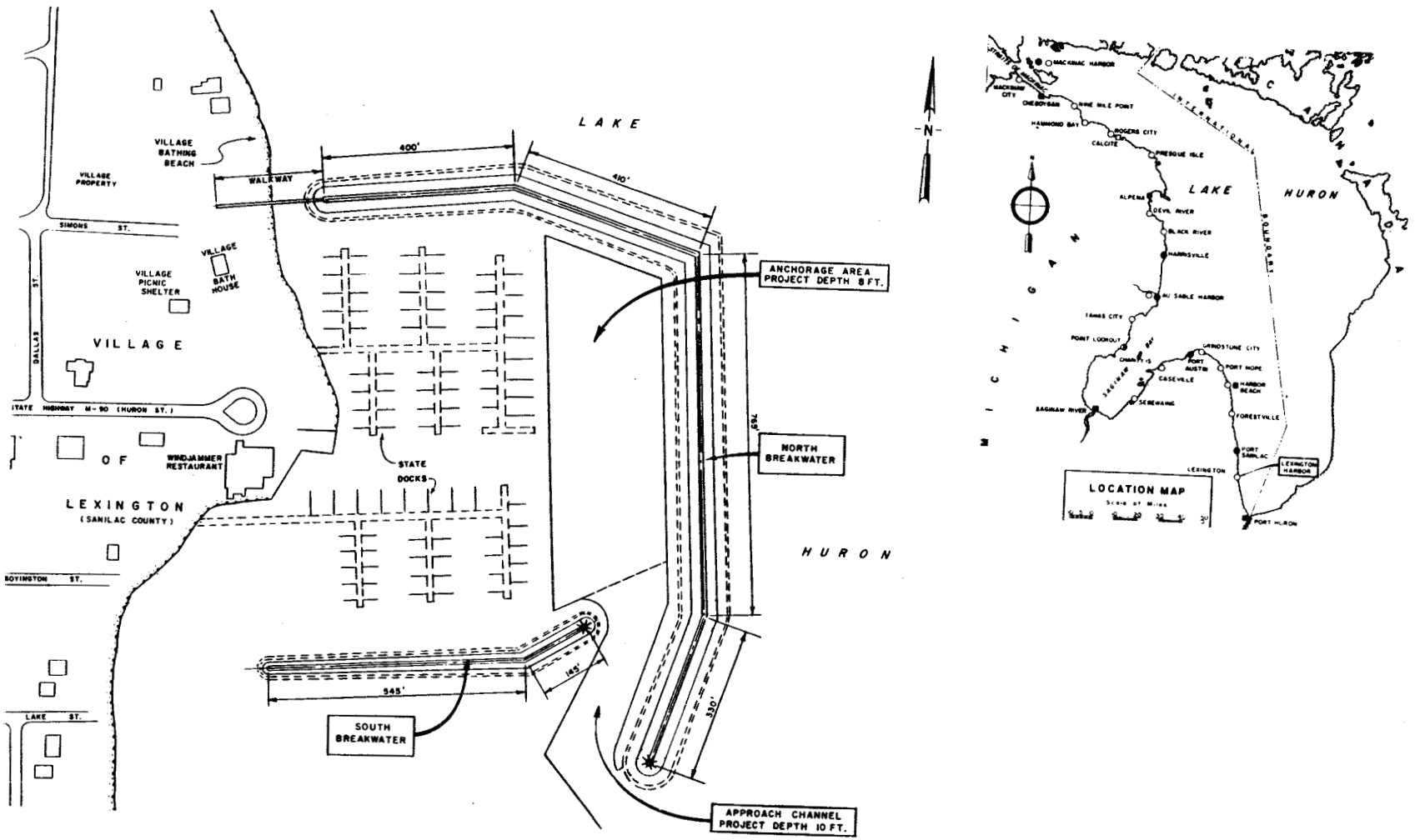
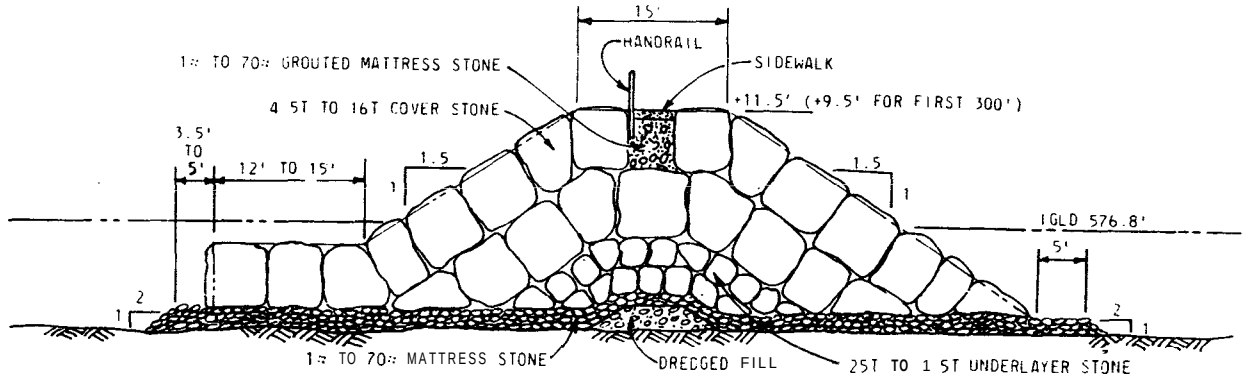
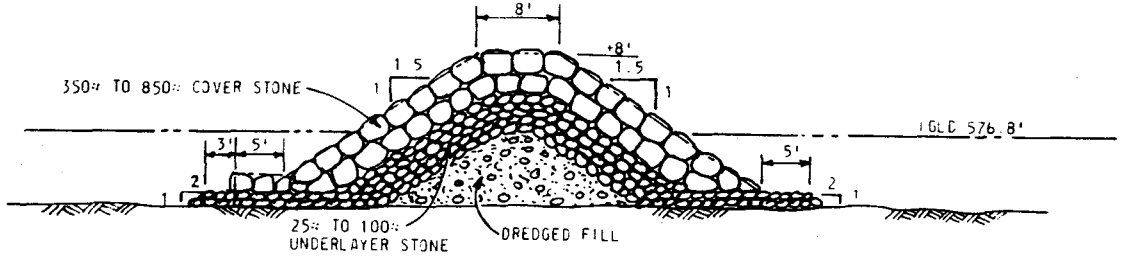


Figure 198. Lexington Harbor, Michigan



TYPICAL CROSS SECTION NORTH BREAKWATER

BUILT 1976



TYPICAL CROSS SECTION SOUTH BREAKWATER

BUILT 1976

Figure 199. Typical breakwater cross sections, Lexington Harbor, Michigan

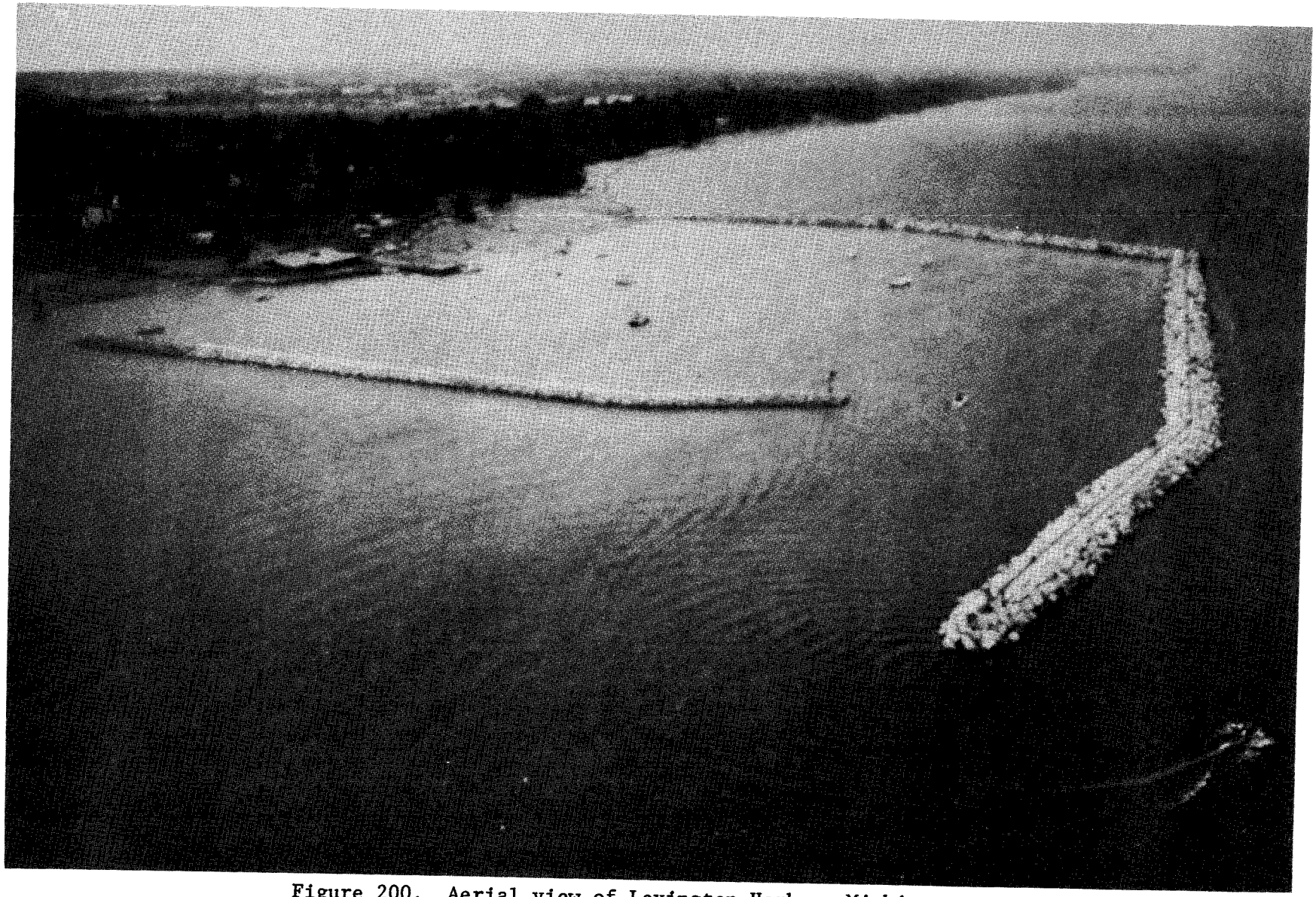


Figure 200. Aerial view of Lexington Harbor, Michigan

Table 75

Clinton River Breakwater

Clinton River, Michigan

Date(s)	Construction and Rehabilitation History
1966	Construction of a 1,400-ft-long rubble-mound breakwater north of the river entrance and an earth fill (Figure 201) was completed. The breakwater had a +6.1 ft lwd crest el, an 8-ft-wide crest width, and 1-V:1.5-H side slopes (Figure 201). Cover stone ranged from 1,000 lb to 1 ton.
1986	There is no record of breakwater maintenance, and the structure presently is in good condition. An aerial photograph of the Clinton River breakwater is shown in Figure 202.

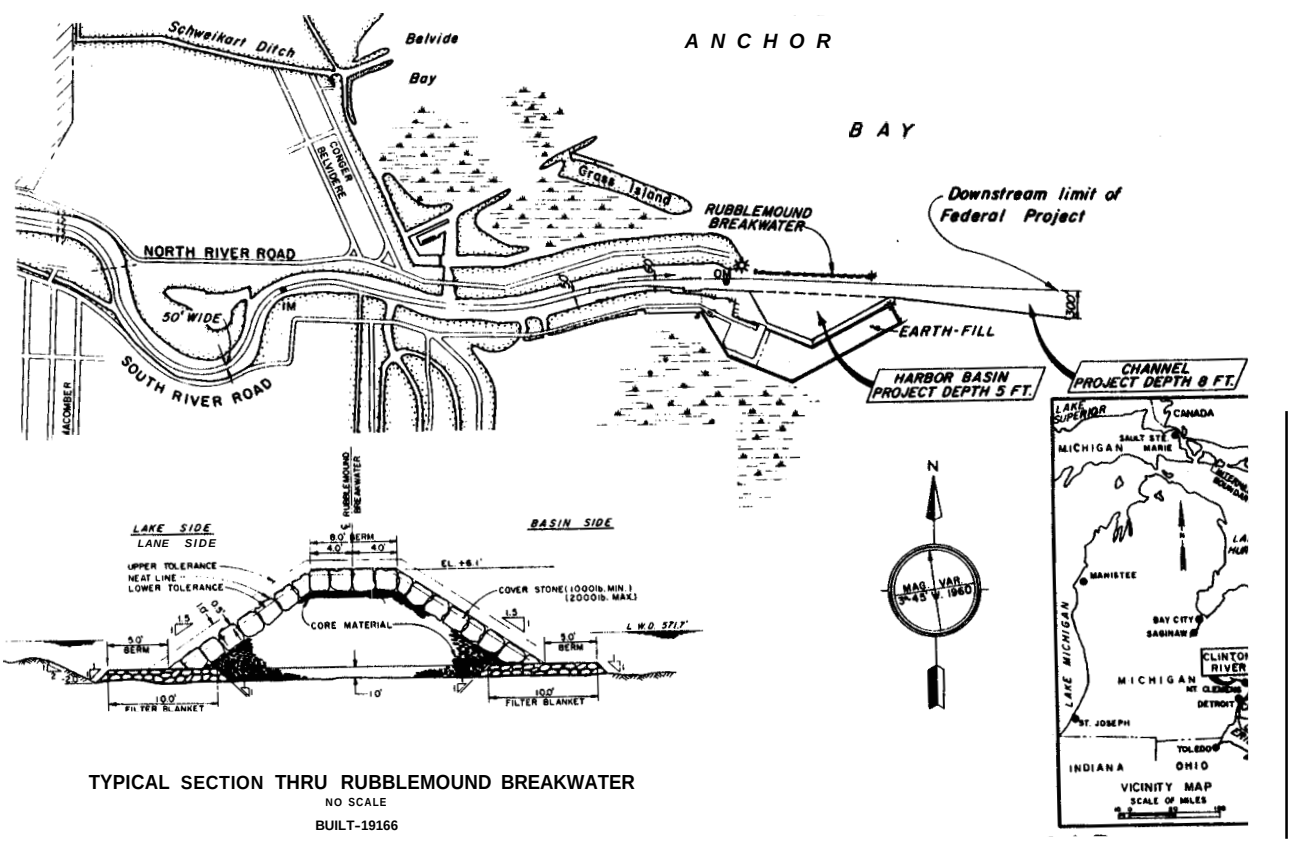


Figure 201. Clinton River Harbor, Michigan

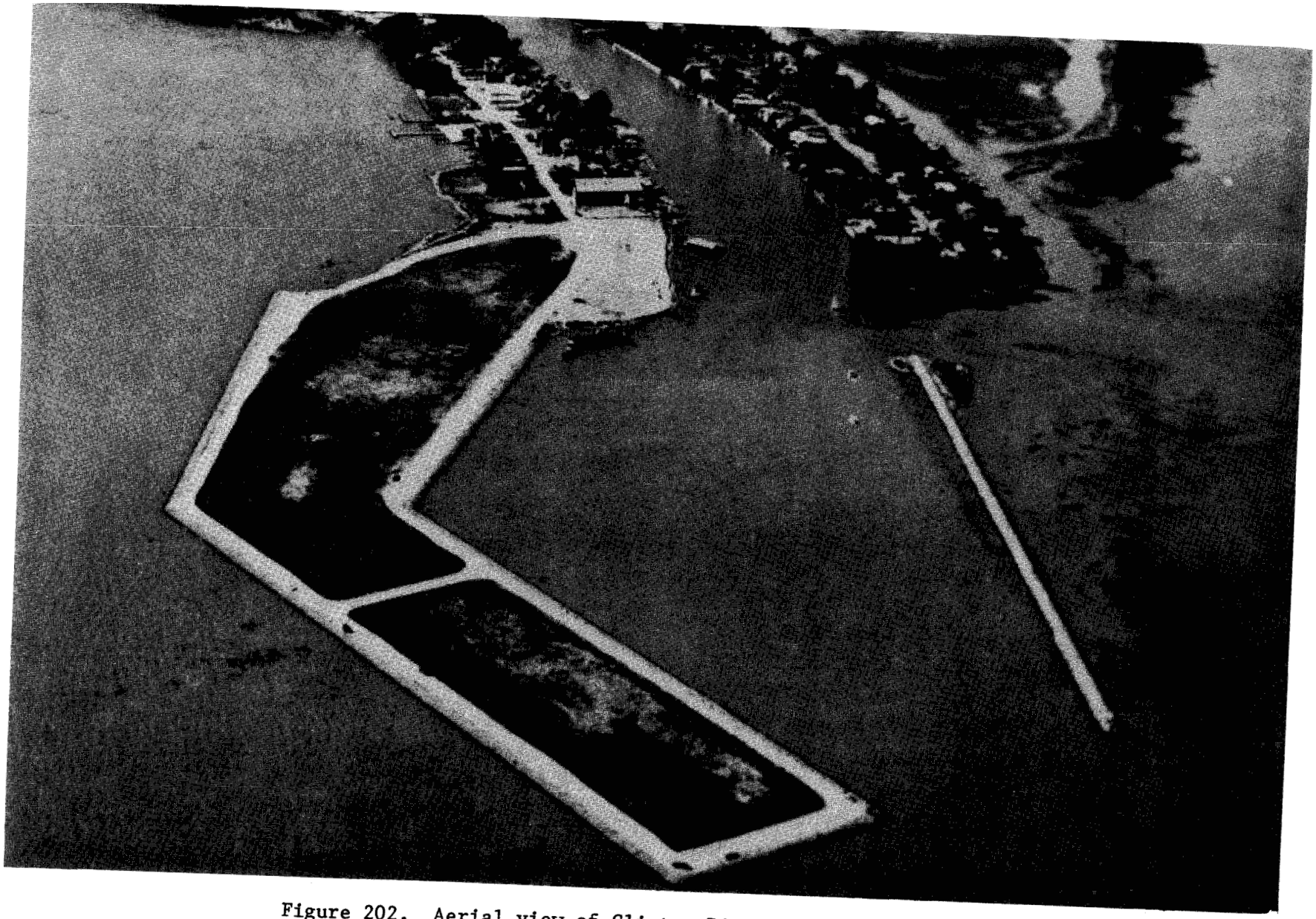


Figure 202. Aerial view of Clinton River Harbor, Michigan

Table 76

Bolles Harbor Jetty:

Bolles Harbor, Michigan

Date(s)	Construction and Rehabilitation History
1970	Construction of a 400-ft-long rubble-mound jetty west of the entrance and a disposal site (Figure 203) was completed. The jetty had a 10-ft crest width and an el of +7.0 ft lwd (Figure 203). It included side slopes of 1V:2H and armor stone ranging from 700 to 1,600 lb.
1984	An inspection of the site indicated the jetty was in good condition. There is no record of jetty maintenance.

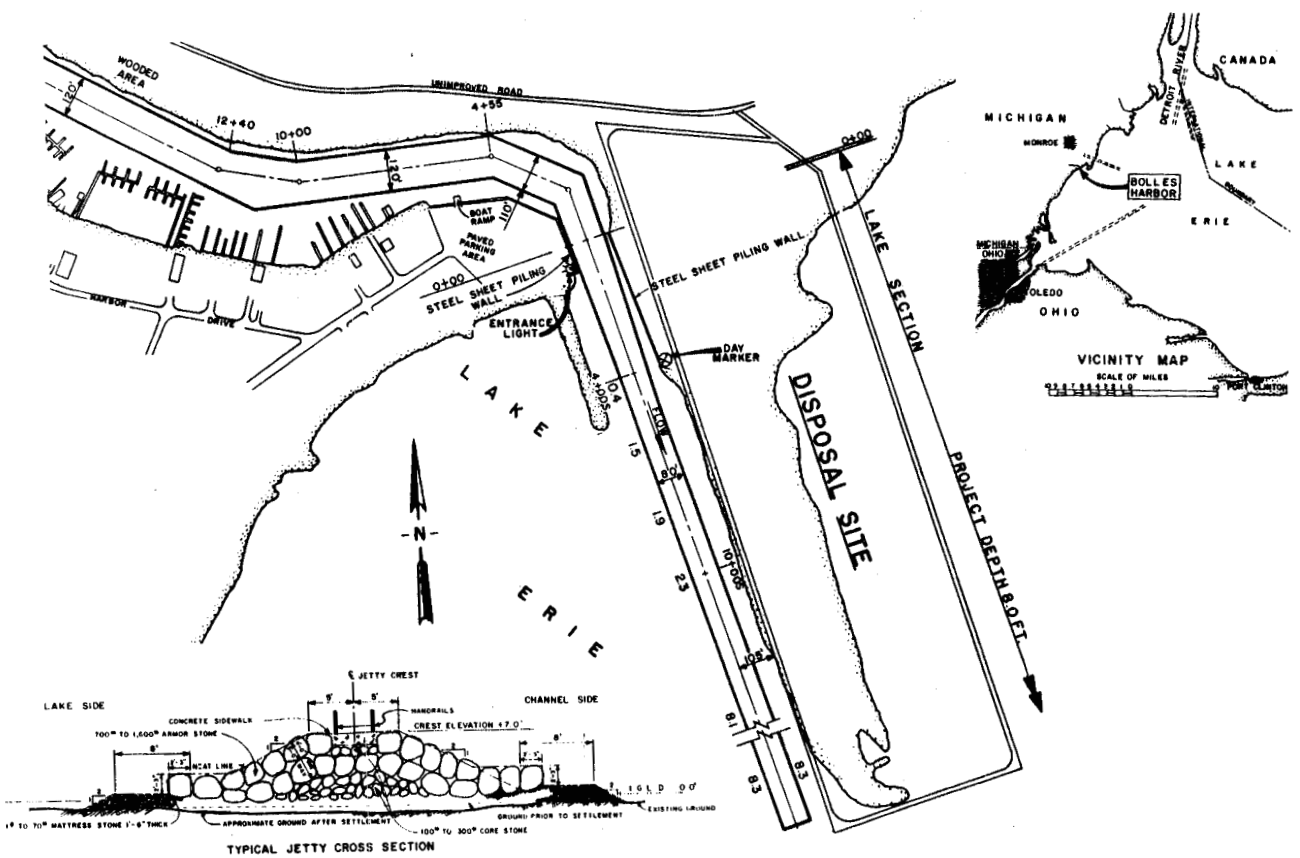


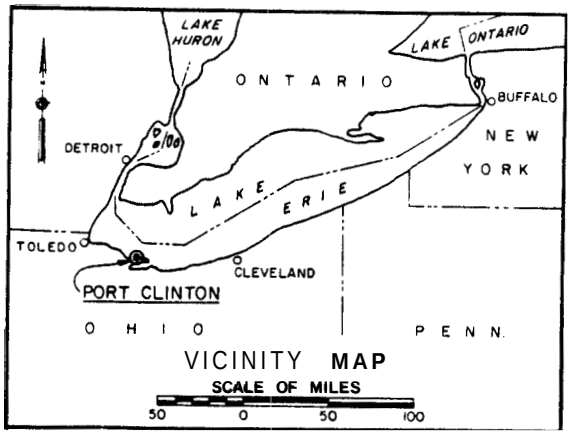
Figure 203. Bolles Harbor, Michigan

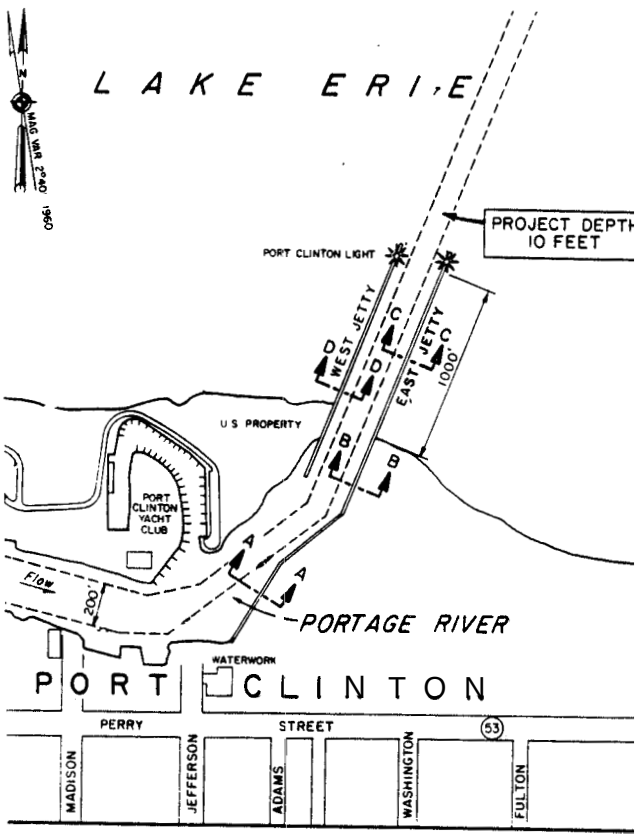
Table 77

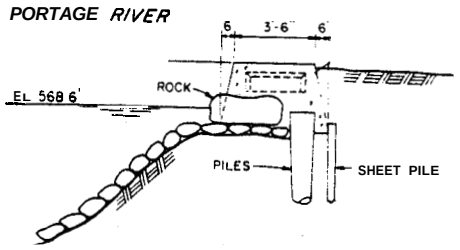
Port Clinton Harbor Jetties

Port Clinton, Ohio

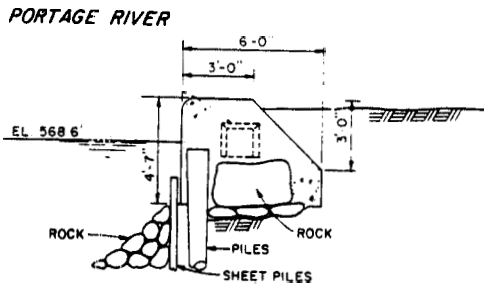
Date(s)	Construction and Rehabilitation History
1893	Construction of parallel jetties extending lakeward from the mouth of the Portage River (Figure 204) was completed. The original lengths of the east and west jetties were 2,200 and 1,980 ft, respectively. The jetties were constructed of woodpiling and stone. Side slopes of the rubble portions of the structures were 1V:1H,
1963	Breakwater repairs were completed for a cost of $12,240.
1973	Placement of stone on various portions of the east jetty was completed to repair areas that were washed out and damaged by a large storm in 1972. The cost of these repairs was $128,860.
1980	An inspection of the site indicated the structures were in very poor condition with the exception of the areas that were repaired in 1973. The jetties were badly deteriorated and sheet pile and additional stone was recommended. It was also recommended that 850 ft of the shore arm of the west jetty be deauthorized since much of it was settled badly and/or buried and it was not considered necessary for shore protection. This deauthorization would result in a west jetty length of 1,130 ft as shown in Figure 204.
1982	Repair of damaged areas of the east jetty was completed. Damaged areas were overlayered with stone similar to that used during construction in 1973. Steel sheetpiling and a concrete cap were installed on the portion of the jetty adjacent to the overbank, and a concrete walkway was installed on the structure originating at the shoreline and extending 1,000 ft lakeward (Figure 204). The crest el of the concrete cap ranged from +3 to +5 ft lwd, and the el of the walkway was +7.25 ft lwd.
1983-1984	Repairs to the west jetty were completed. Armor stone was placed along the lakeside and the crest of the existing jetty. These stones ranged from 0.5 to 3.5 tons. The crest el after the repairs was +7.3 ft lwd.
1986	The structures are presently considered to be in good condition. An aerial view of the Port Clinton Harbor Jetties is shown in Figure 205.



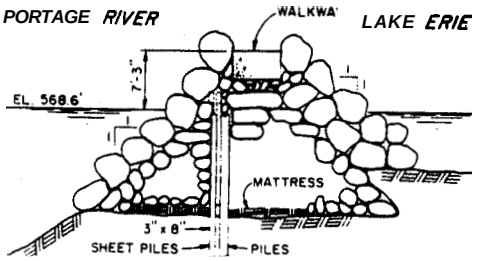




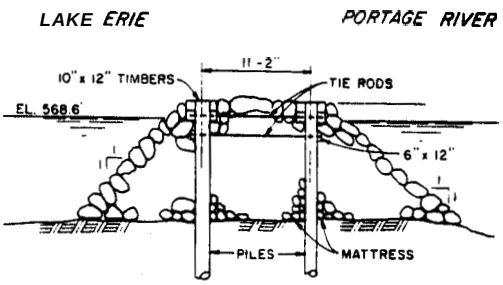
SECTION A-A



SECTION B-B



SECTION C-C



SECTION D-D

Figure 204. Port Clinton Harbor, Ohio

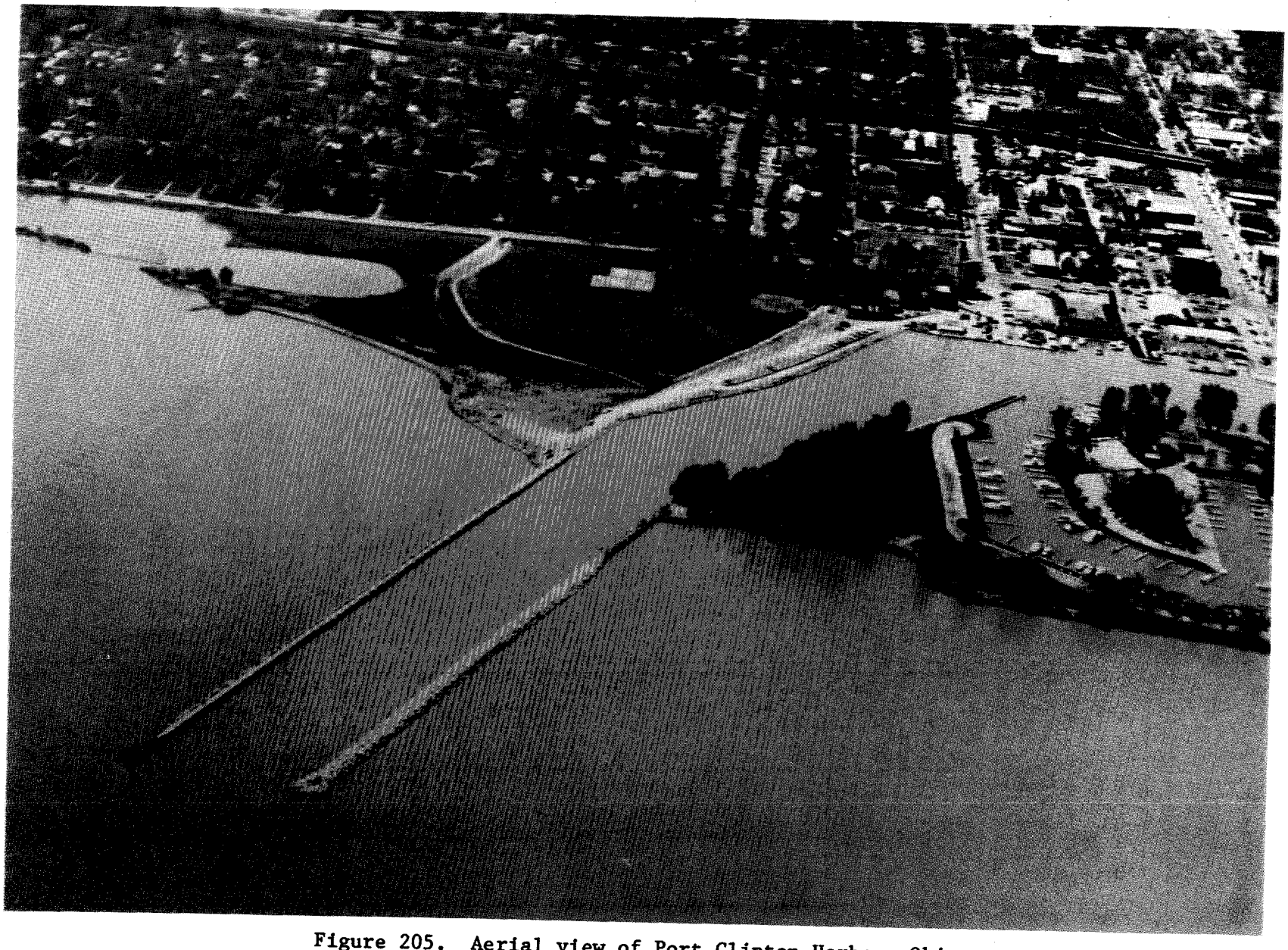


Figure 205. Aerial view of Port Clinton Harbor, Ohio

Table 78

West Harbor Breakwaters

Ottawa County, Ohio

Date(s)	Construction and Rehabilitation History
1982	Construction of two breakwaters in an arrowhead configuration extending lakeward on each side of the natural entrance (Figure 206) was completed. The north and south breakwaters were rubble-mound structures with lengths of 1,350 and 1,575 ft, respectively. The structures had 10-ft-wide crest widths and els of +6.9 ft lwd (Figure 207). Armor stone ranged from 1 to 3 tons, and side slopes were 1V:1.5H on the breakwater trunks and 1V:3H at the heads.
1986	There is no record of maintenance or repairs to the breakwaters, and they presently are considered to be in good condition. An aerial view of the West Harbor breakwaters is shown in Figure 208.

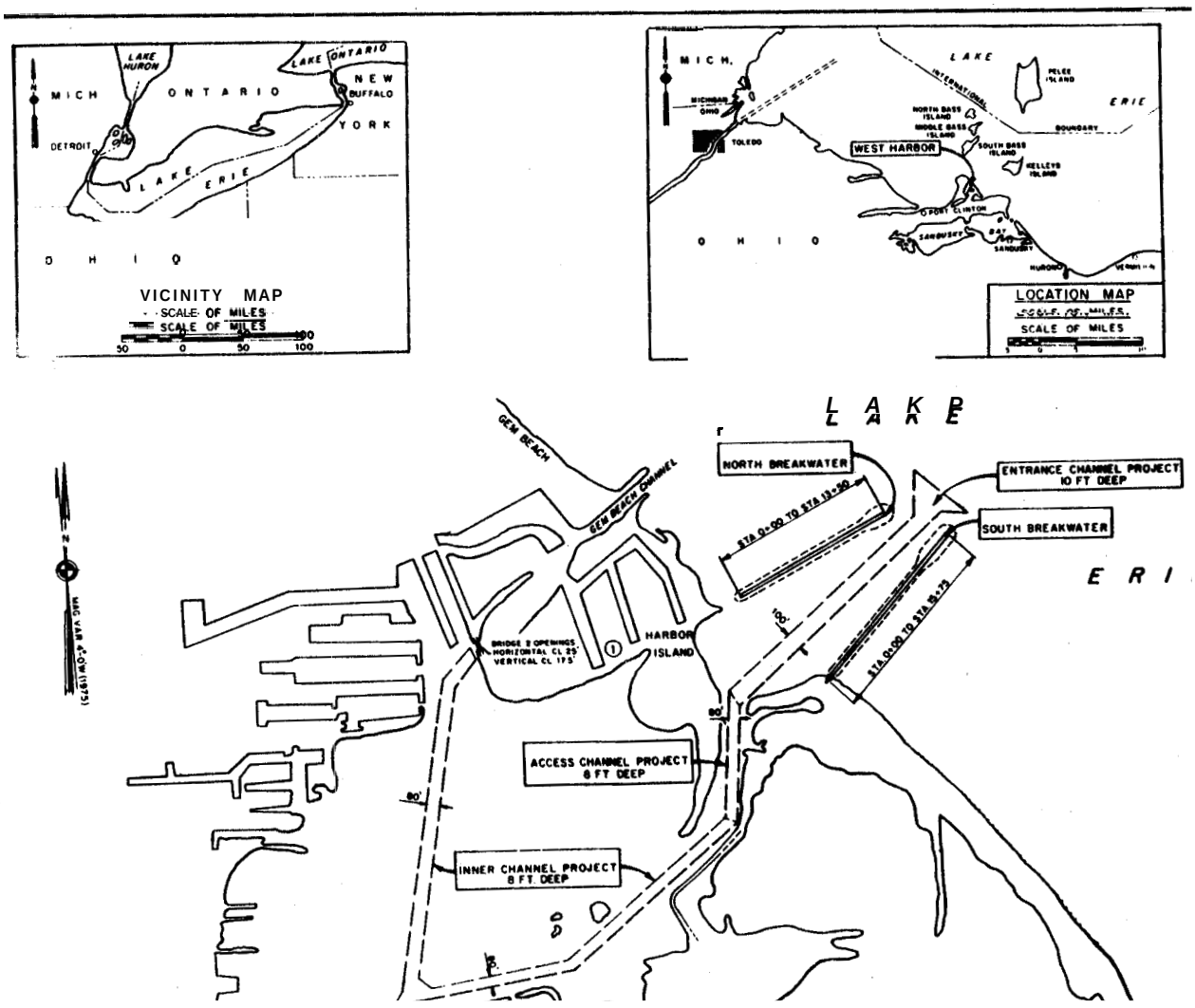
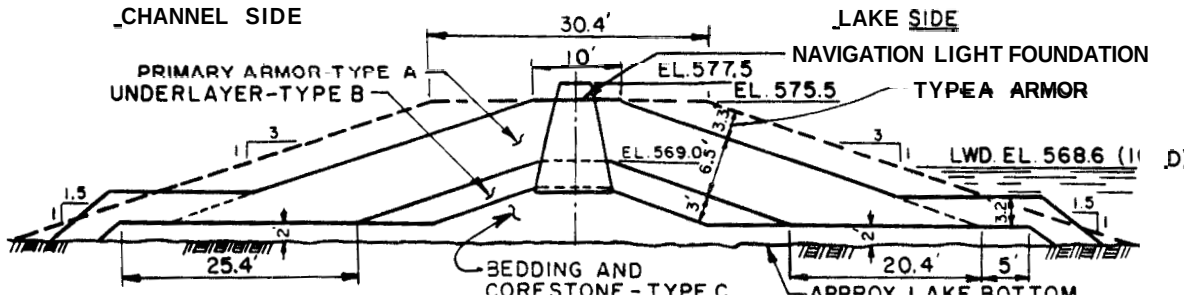


Figure 206. West Harbor, Ohio

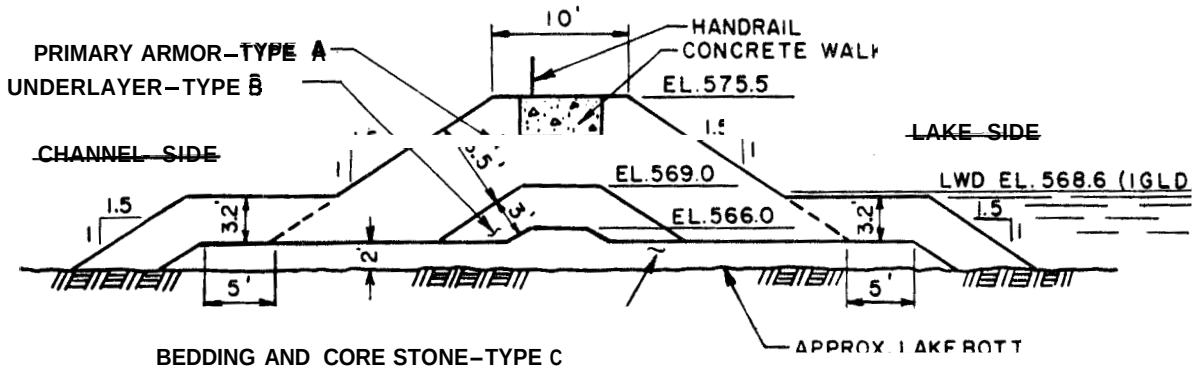
STONE GRADATION

TYPE "A" STONE 1 - 3 TONS
TYPE "B" STONE 200 -700 POUNDS
TYPE "C" STONE 0.5-50 POUNDS



TYPICAL HEAD SECTION

STA. 0+00 TO 1+00 ARMOR LAYER 9.8FT THICK (NORTH AND SOUTH BKW)
STA. 1+00 TO 2+00 ARMOR LAYER 6.5FT. THICK (SOUTH ONLY)



TYPICAL OUTER TRUNK SECTION

STA 3+20 TO 5+00

TYPICAL BREAKWATER SECTIONS

Figure 207. Typical breakwater cross sections, West Harbor, Ohio

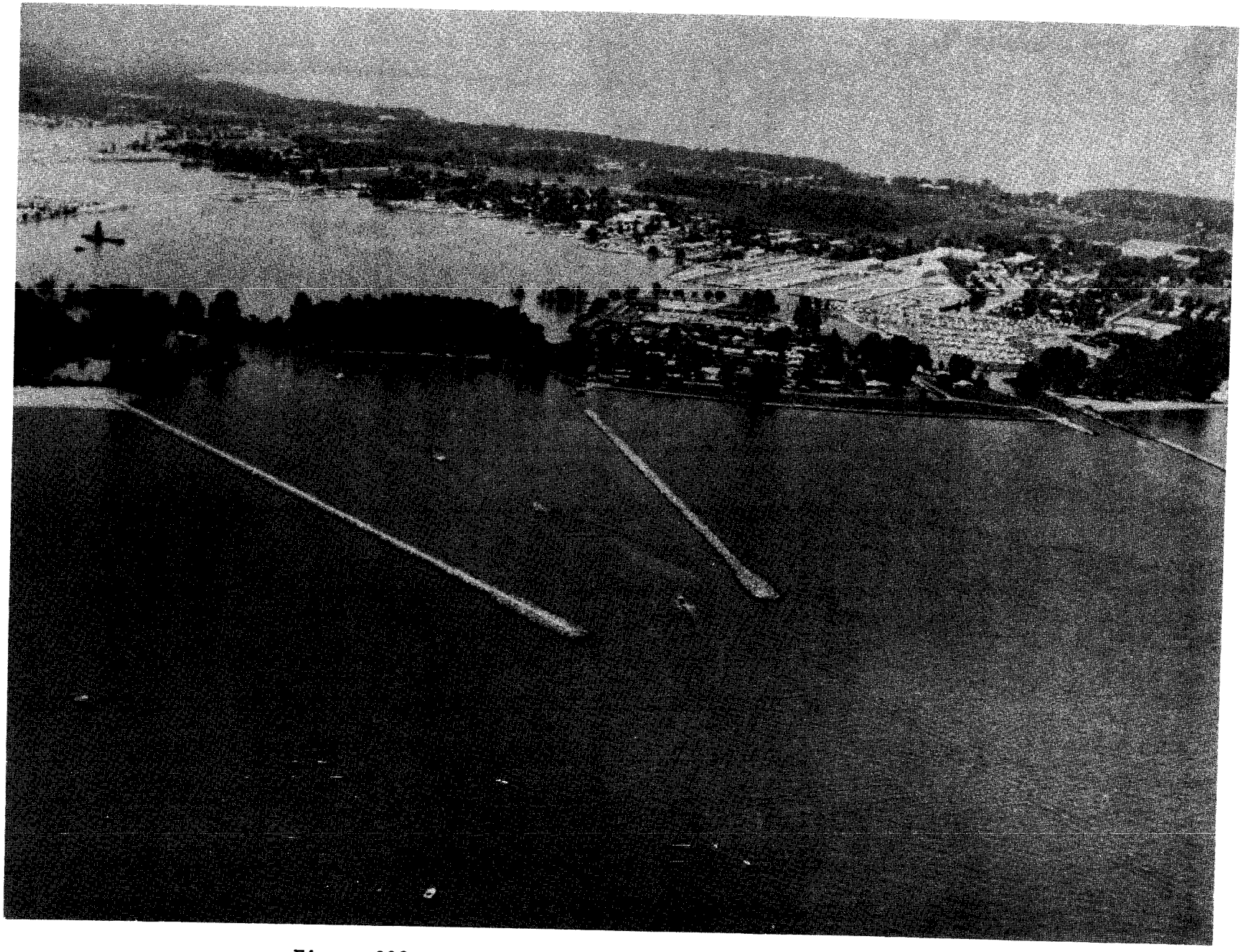


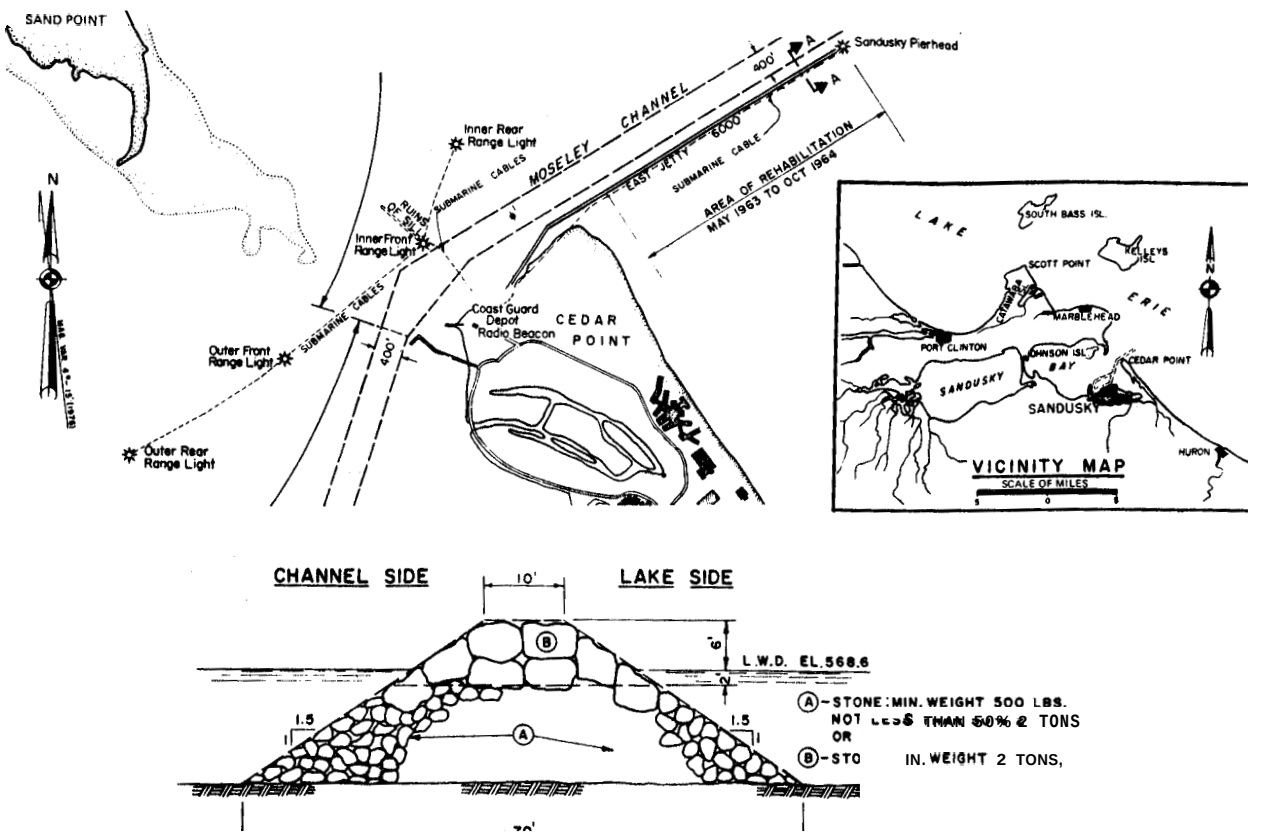
Figure 208. Aerial view of West Harbor, Ohio

Table 79

Sandusky Harbor East Jetty

Sandusky, Ohio

Date(s)	Construction and Rehabilitation History
1897-1922	Construction of a 6,000-ft-long rubble-mound east jetty was completed (Figure 209) during this time. The jetty had a 10-ft-wide crest with an el of +6.0 ft lwd and side slopes of 1V:1.5H. Armor stone used from an el of about -2 ft lwd to the crest had a minimum weight of 2 tons. Stone used below this el (-2 ft lwd) had a minimum weight of 500 lb and not less than 50 percent was 2 tons or more.
1963-1964	Rehabilitation of the lakeward 4,000-ft portion of the jetty was completed during this time. The el of the jetty was raised to its authorized height of +6 ft lwd. Armor stone with a minimum weight of 4 tons each was used.
1985	The east jetty was considered to be in poor condition, and repairs were recommended. Estimated costs of these repairs were about $84,000.



SECTION OF EAST JETTY (A-A)
(BUILT 1897–1922)

Figure 209. Sandusky Harbor, Ohio

Table 80

Huron Harbor Structures

Huron, Ohio

Date(s)	Construction and Rehabilitation History
1827-1831	Construction of an 800-ft-long west pier (Figure 210, Section A) was completed. The pier was a 20-ft-wide stone-filled timber crib structure (Figure 211, Section A).
1891-1894	A 973-ft-long extension of the west pier (Figure 210, Sections C and G) was completed. The extension consisted of a stone-filled timber crib structure that ranged from 16 to 20 ft in width (Figure 211, Section C).
1907-1908	Construction of a 1,450-ft-long rubble-mound east breakwater (Figure 210, Section B) was completed during this time. The breakwater had a crest width of 10 ft and an el of +10.3 ft lwd (Figure 212, Section B). Side slopes were 1V:2H on the lakeside and 1V:1.34 on the harbor side. A concrete and stone superstructure was installed on a portion of the west pier (Figures 210 and 211, Section C) also during this period of time. The crest el of the pier was +8.3 ft lwd.
1914	A 280-ft-long shoreward extension of the west pier (Figure 210, Sections D and F) was completed. The lakeward portion of the extension involved woodpilings driven about 15 ft apart and filled with stone (Figure 212, Section D). The extension was capped with larger stone (5-ton minimum) and had a crest el of about +6.0 ft lwd. The adjacent 160-ft-long shoreward portion of the extension (Figure 212, Section F) was a rubble-mound structure with a crest width of 5 ft and an el of +5 ft lwd. Side slopes were 1V:1H.
1925	A concrete superstructure was installed on an 800-ft-long portion of the west pier (Figures 210 and 211, Section A). The crest el of this portion of the pier was +6.3 ft lwd.
1930	The shoreward rubble-mound portion of the west pier constructed in 1914 (Figures 210 and 212, Section F) was repaired and extended shoreward an additional 110 ft.
1933-1934	A 1,360-ft-long rubble-mound extension of the west pier (Figure 210, Section E) was constructed during this period. The breakwater had a crest width of about 8 ft and an el of +8 ft lwd. Side slopes were 1V:1.3H (Figure 211, Section E). Armor stones with a minimum weight of 3 tons, and not less than 50 percent being 5 tons or more, were used.
1950	A 242-ft-long portion of the west pier was repaired by encasing it with steel sheetpiling (Figures 210 and 211, Section C). The voids between the sheetpiling and the existing structure were filled with

(Continued)

Table 80 (Concluded)

Date(s)	Construction and Rehabilitation History
	stone and a concrete cap was installed. The width of the pier varied from 24 to 28 ft, and the crest el ranged from +8.4 to +9.4 ft lwd.
1957	A 341-ft-long portion of the west pier was repaired (Figures 210 and 211, Section C) in the same manner as the 1950 repairs.
1963	A 390-ft-long portion of the west pier was repaired (Figures 210 and 211, Section G) in a manner similar to the 1950 and 1951 repairs. The structure width, however, was 34.7 ft, and the crest el was +8.75 ft.
1975	Reconstruction of the portion of the west pier adjacent to the Corps disposal area (Figure 210) was completed. The rubble- mound portion of the pier (Section E) was raised to an el of +15.25 ft lwd and had a crest el of 8 ft (Figure 211). The steel sheet-pile encased portion of the pier (Sections C and G) included the installation of stone adjacent to the containment side of the pier (Figure 211). The crest el of the stone structure was 10.25 ft lwd, and the crest width was 8.5 ft. A parapet was installed at an el of +11.0 ft on the encased structure adjacent to the stone crest.
1984	Many repairs have been performed during the structure's lifetime, and they are considered to be in fair condition. An aerial photo of the Huron Harbor structures is shown in Figure 213.

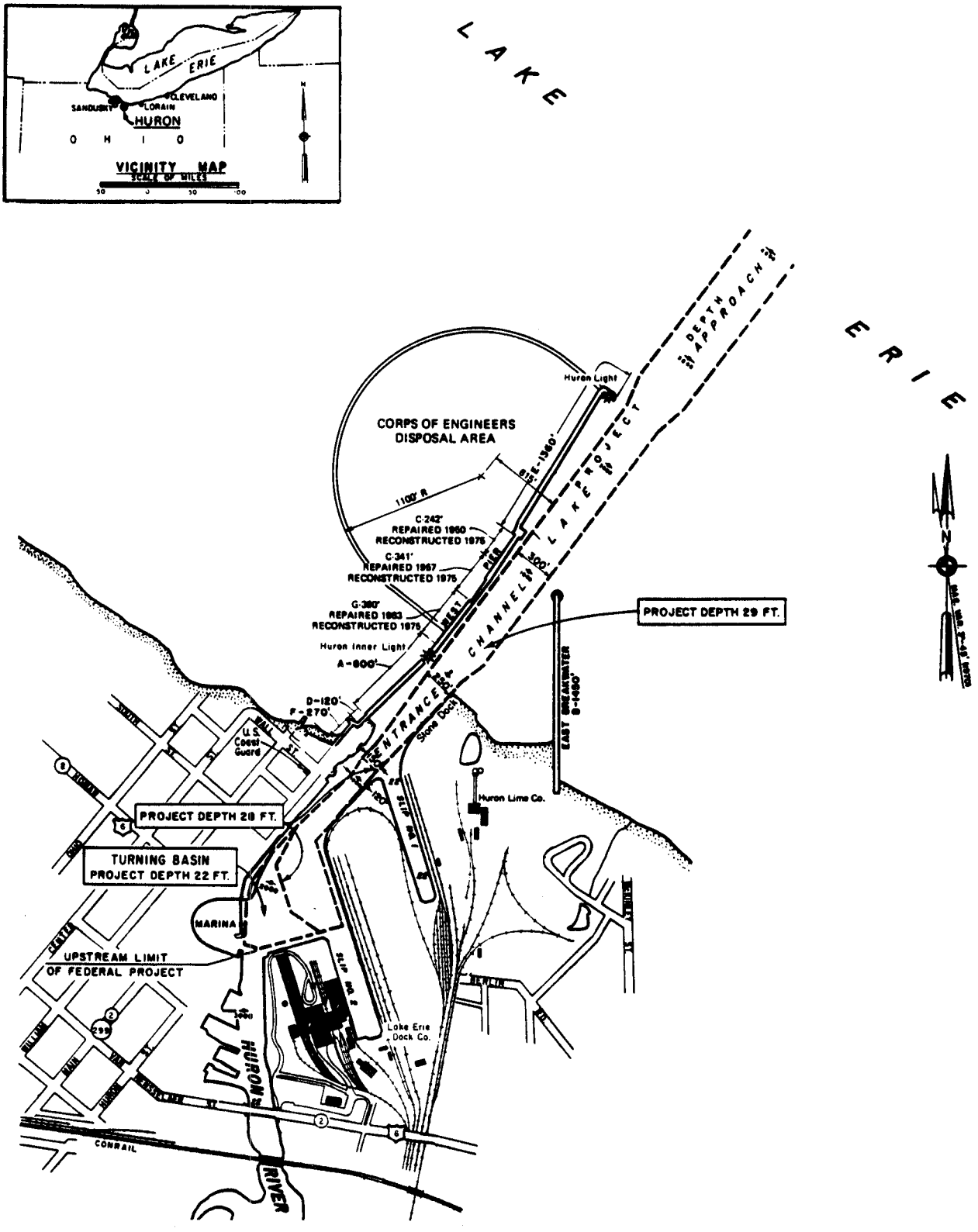
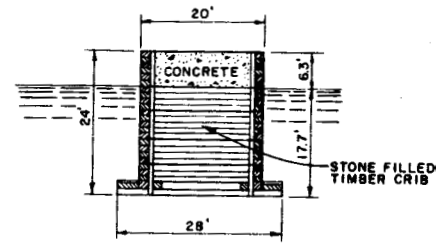


Figure 210. **Huron Harbor, Ohio**



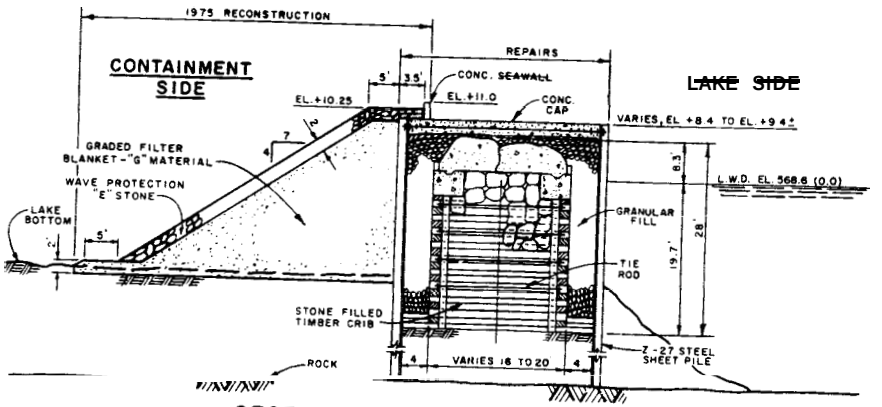
SECTION OF WEST PIER AT -A-

(BUILT 1027-1831)

SUPERSTRUCTURE BUILT 1925

STONE GRADATION

Deck Stone	Min. weight 5 tons.
"A" Stone	Min. weight 3 tons not less thon 50% 5 tons or mora.
"B" Stone	Mln. welght 100 lbs.
"C" Stone	Not less thon 35% 75 lbs. or more not less than 3% less than 1 lb.
"D" Stone	Mln. weight 25 lbs.-Maximum weight 1200 lbs.
"E" Stone	Min. weight 25 lbs. - Maximum weight 400 lbs.
"F" Stone	Min. weight 3 lbs. - Maximum weight 100 lbs.
"G" Mat'l	200 sieve to Moa. weight 125 lbs.



SECTION OF WEST PIER AT -C-

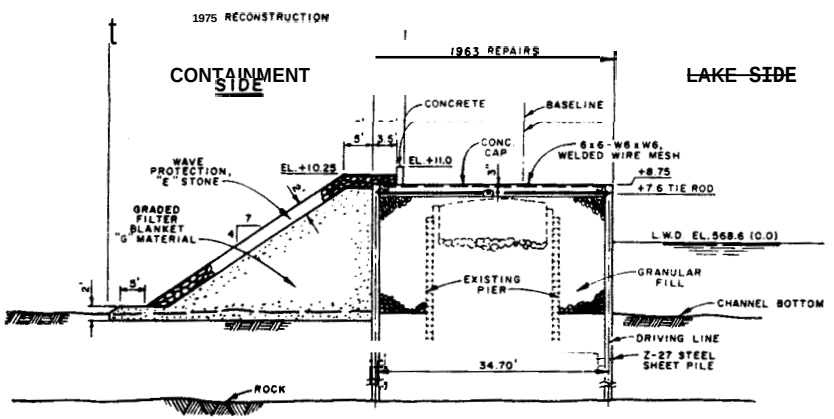
(BUILT 1891 - 1894)

SUPERSTRUCTURE 1907-1908

REBUILT 242 FEET OF PIER 1950

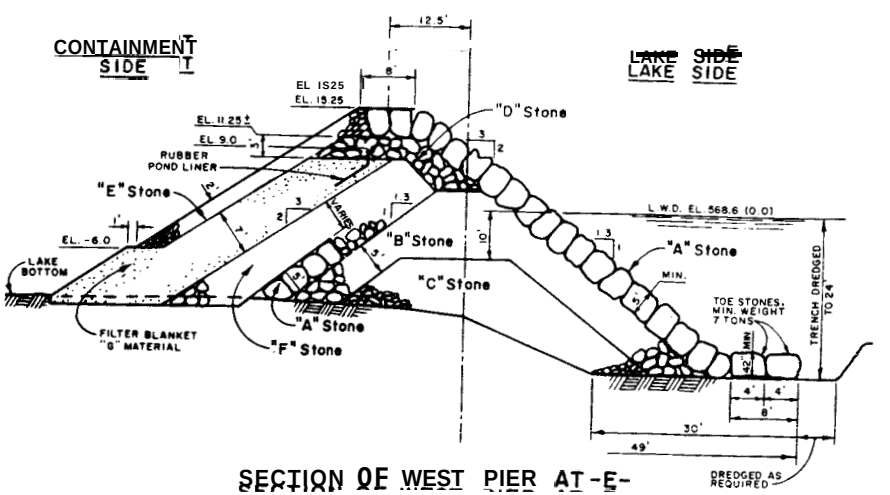
REBUILT 341 FEET OF PIER 1957

FILTER BLANKET, WAVE PROTECTION AND SEAWALL ADDED IN 1975



SECTION OF REPAIRS TO 390 FEET OF WEST PIER MADE IN 1963 AT-G

FILTER BLANKET WAVE PROTECTION

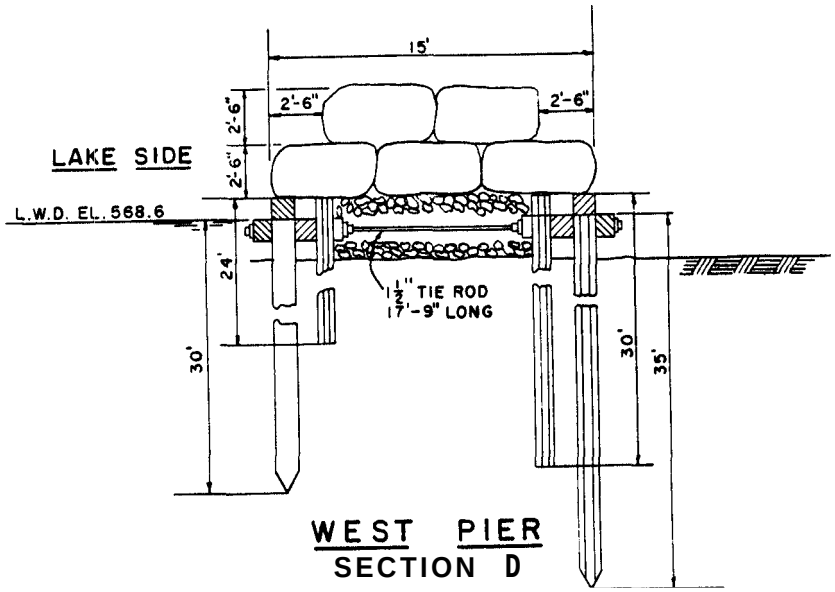


SECTION OF WEST PIER AT -E-

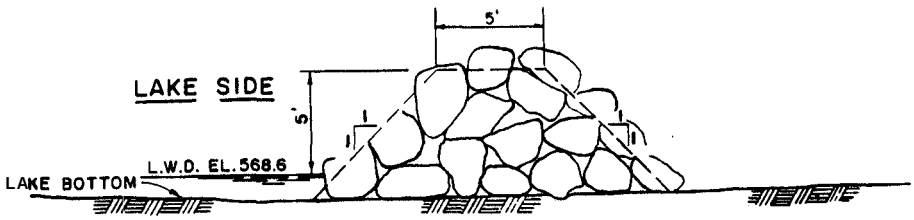
(BUILT 1933- 1934)

RECONSTRUCTED 1975

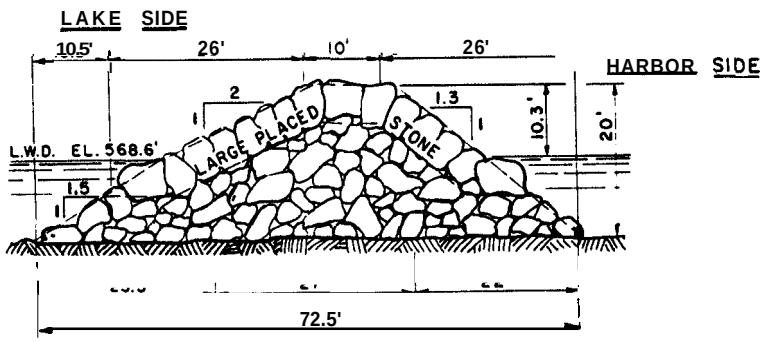
Figure 211. Typical pier cross sections, Huron Harbor, Ohio



WEST PIER
SECTION D
(BUILT IN 1914)



WEST PIER
SECTION F
(BUILT 160'-1914
BUILT 110'-1930)



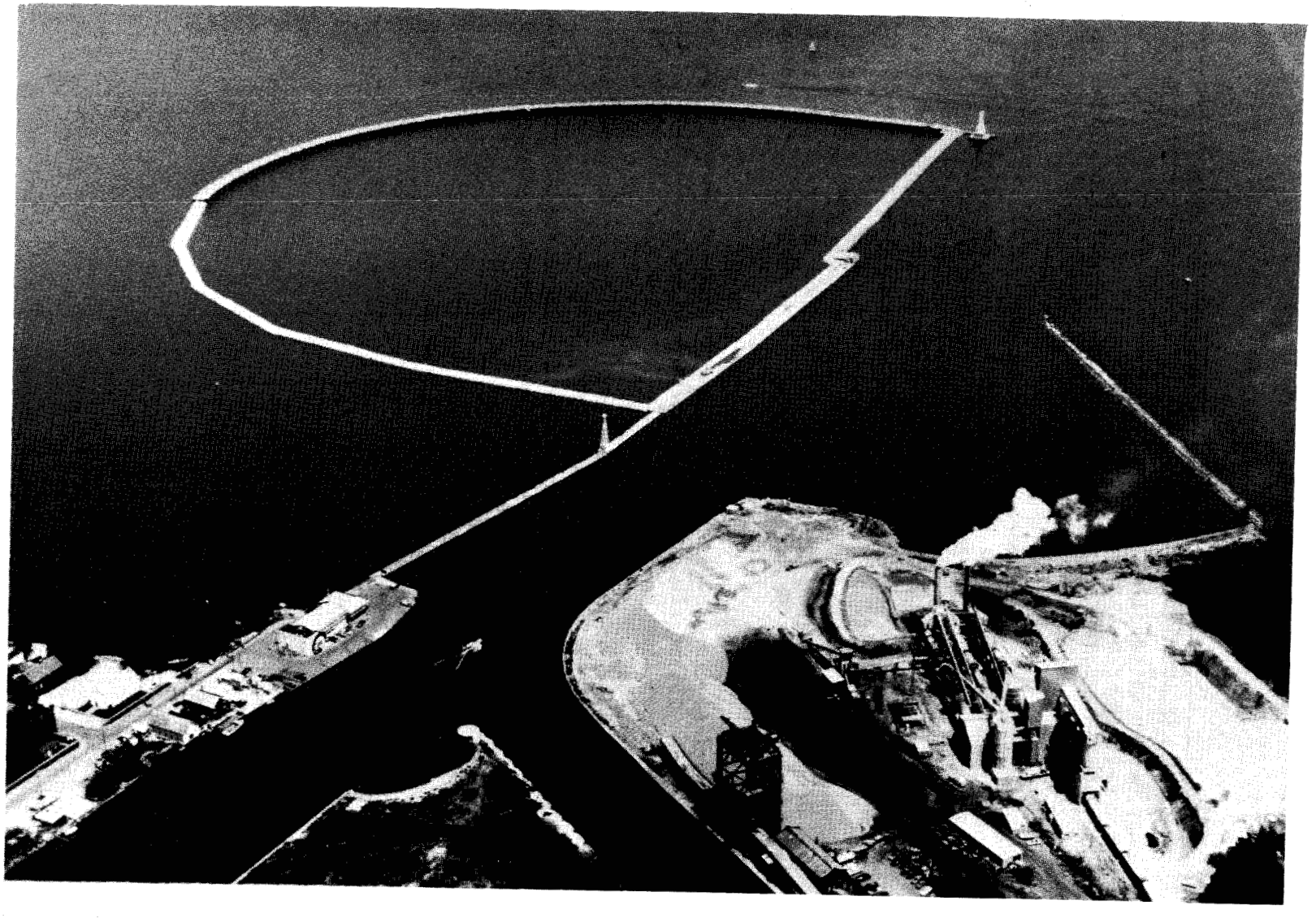


Figure 213. Aerial view of Huron Harbor, Ohio

Table 81

Vermilion Harbor Structures

Vermilion, Ohio

Date(s)	Construction and Rehabilitation History
1836-1839	Construction of parallel piers at the mouth of the Vermilion River was completed, The piers extended to the -10 ft lwd contour and had crest els of about +5.0 ft lwd. They were stone-filled timber crib structures, and were 16 ft in width.
1874	The east and west piers were extended to the -12 ft lwd contour. No other laksward extensions have been made. The east pier is 458.5 ft long, and the west pier is 1,333.5 ft long (Figure 214).
1906-1914	A heavy stone superstructure was installed on both piers (Figure 215) to els ranging from +6 to +6.5 ft lwd. The crest width was 10 ft.
1964	Rehabilitation of 450 ft of the west pier and 230 ft of the east pier was completed (Figures 214 and 215). The crest els of these portions were raised to +6.5 ft lwd, and riprap was installed on the lakesides of the structures.
1973	Construction of an 864-ft-long detached breakwater (Figure 214) was completed. The breakwater was a cellular steel sheet-pile structure with 35-ft diameter cells. The cells were granular filled and capped with concrete at an el of +10 ft lwd (Figure 215). The offshore breakwater was model tested (Brasfield 1970) prior to construction.
1986	The structures presently are considered in good condition. An aerial view of the Vermilion Harbor structures is shown in Figure 216.

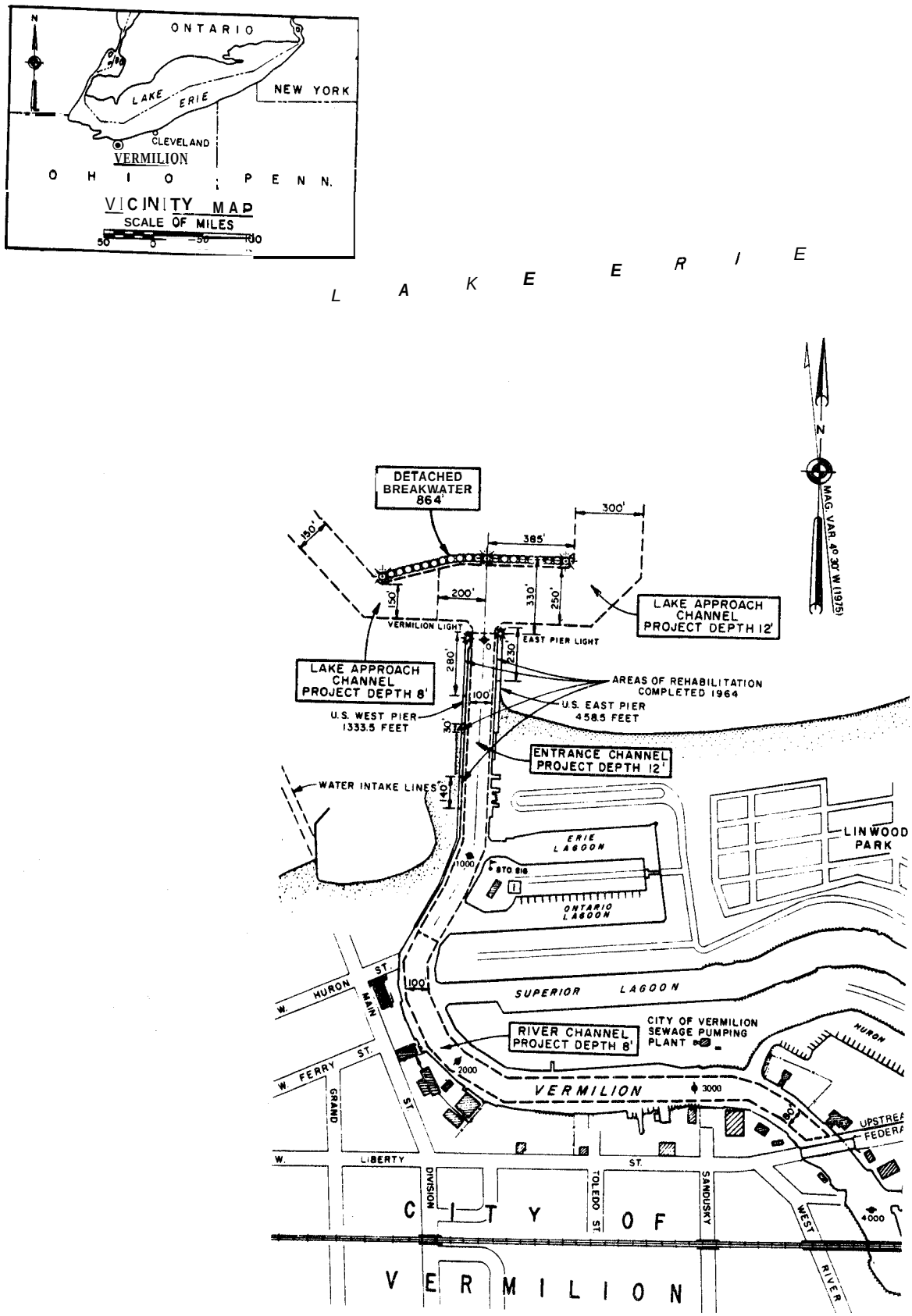
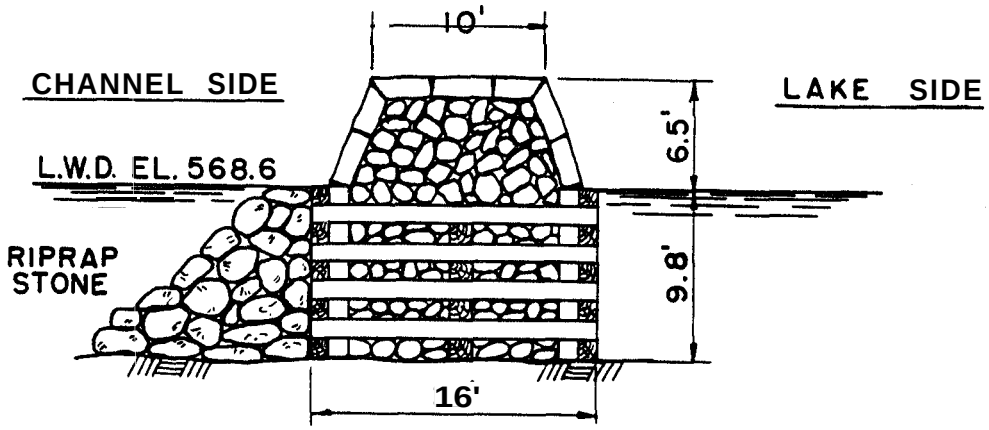


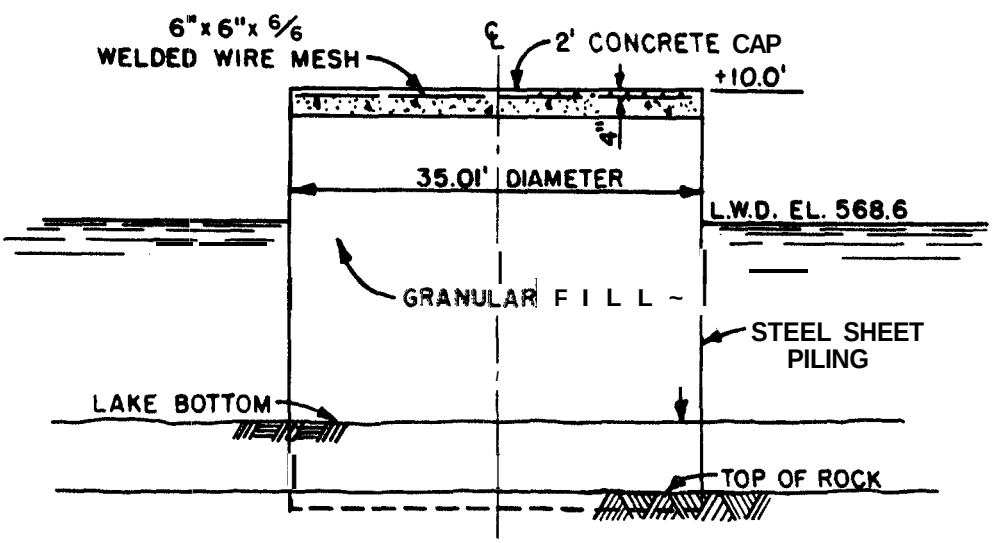
Figure 214. Vermilion Harbor, Ohio



SECTION OF EAST PIER

WEST PIER SIMILAR BUT OPPOSITE HAND
(BUILT 1836-1839, REBUILT 1906-1914)

REHABILITATION OF 450 FEET OF WEST PIER AND 230 FEET OF EAST PIER INITIATED IN JUNE 1964 AND COMPLETED IN OCTOBER 1964. (TOP ELEVATION RAISED TO 6.5 FEET ABOVE L.W.D. AND RIPRAP STONE PLACED ON LAKE SIDIE.)



DETACHED BREAKWATER

(BUILT 19731

Figure 215. Typical structure cross sections, Vermilion Harbor, Ohio

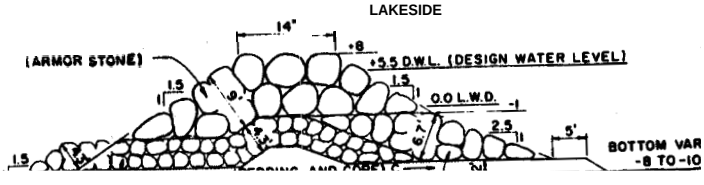
Figure 216. Aerial view of Vermilion Harbor, Ohio

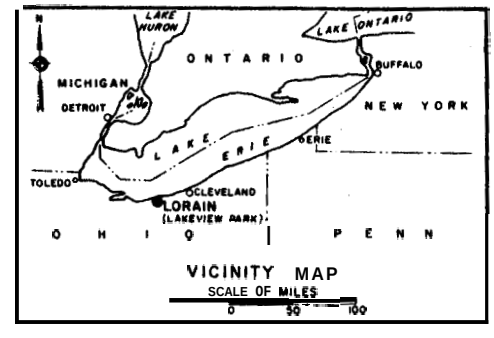
Table 82

Lakeview Park Breakwaters

Lorain, Ohio

Date(s)	Construction and Rehabilitation History
1977	Construction of three 250-ft-long offshore breakwaters was completed at the site (Figure 217). The breakwaters were rubble-mound structures with +8 ft lwd crest els and 14-ft-wide crest widths (Figure 217). Side slopes were 1V:1.5H, and armor stone ranged from 4.5 (min) to 10 tons (max).
1982	Model tests (Bottin 1982a) were conducted to determine causes of erosion of the beach fill. Improvement plans consisted of modifications to the west end of the west breakwater and the west groin.
1986	There is no record of repairs to the breakwaters, nor have any improvements been made. The breakwaters are in good condition. An aerial view of the Lakeview Park breakwaters is shown in Figure 218.





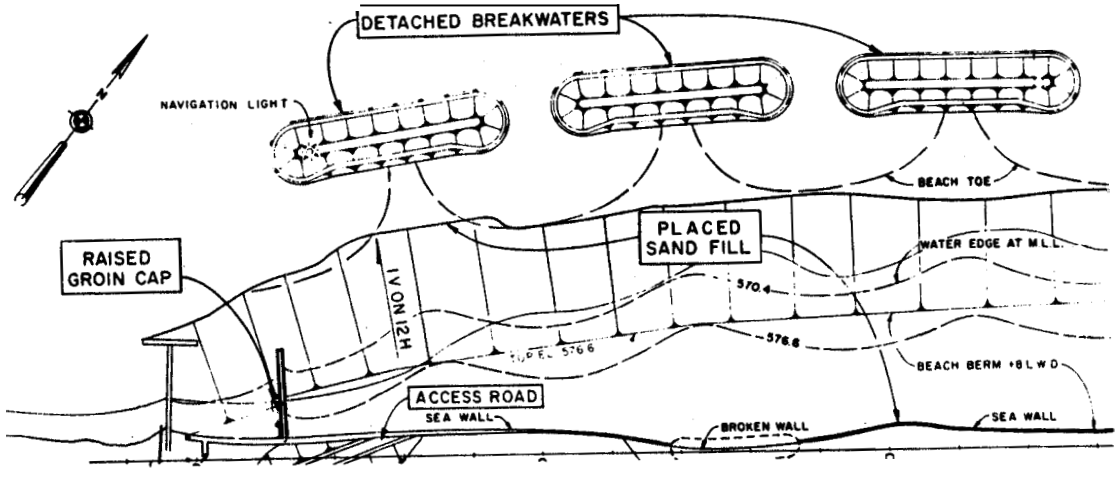


Figure 217. Lakeview Park, Ohio

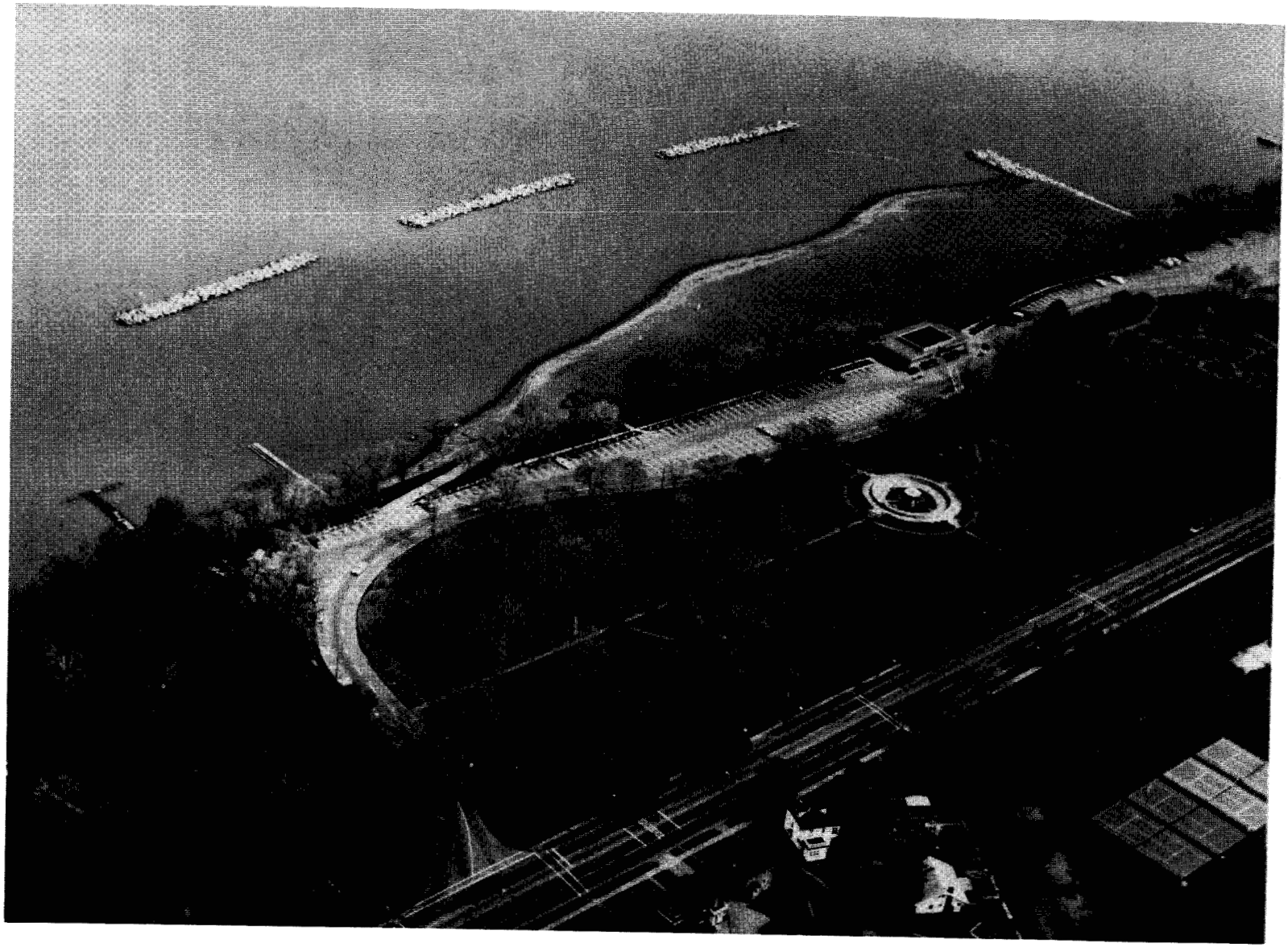


Figure 218. Aerial view of Lakeview Park, Ohio

Table 83

Lorain Harbor Structures

Lorain, Ohio

Date(s)	Construction and Rehabilitation History
1828-1896	Construction of two stone-filled timber crib piers was completed at the mouth of the Black River (Figure 219) during this time. The east pier was originally 1,875 ft long, and the west pier was 1,004-ft long. The east pier was 20 ft wide, and the west pier ranged from 17 to 23 ft wide (Figure 220).
1897-1908	The east and west piers were capped with concrete superstructures (Figure 220). The crest els of the piers were +8.2 ft lwd.
1901-1915	Construction of two detached rubble-mound breakwaters (Figure 219) was completed. The east and west breakwaters were 2,300 and 2,811.5 ft: long, respectively. The structures had crest els of +10.2 ft lwd and crest widths of 10 ft. Side slopes were 1V:3H on the lakeside and 1V:1.3H on the harbor side. Armor stones used were 3 tons (minimum).
1921	The west breakwater was extended to shore (Figure 219). The extension was of rubble-mound construction and originated at the shore end of the existing west breakwater extending shoreward 438.5 ft. At this point there was a 75-ft gap and then a 750-ft-long extension to the shore. The structure had a crest el of +3.9 ft lwd with a width of 5 ft (Figure 220). Armor stone was 2 tons (minimum).
1963	Construction of a 2,457-ft-long east breakwater shore arm (Figure 219) was completed at a cost of about $2.7 million. The outer 2,323 ft was a granular-filled concrete capped cellular steel sheet-pile structure. The cells had a 35-ft diameter with a crest el of +10 ft lwd (Figure 221). Also included was a 134-ft-long rubble-mound shore connection (Figure 219). The rubble-mound portion had a crest el of +10 ft lwd and was capped with rectangular blocks (Figure 221).
1964-1965	The lakeward 995-ft portion of the east pier was removed leaving an 880-ft-long pier, and the lakeward 280-ft portion of the east breakwater was removed resulting in a structure 2,020 ft in length (Figure 219). A 2,180-ft-long granular-filled cellular steel sheet-pile outer breakwater was constructed (Figure 219). Cell diameters were 46.15 ft, and the breakwater was capped with concrete to an el of +10 ft lwd (Figure 221). Riprap toe protection also was placed adjacent to both sides of the breakwater. This modification was model tested (Wilson, Hudson, and Housley 1963).
1977	A combination rubble-mound and steel sheet-pile dredge disposal dike was constructed and attached to the east breakwater shorearm.
1986	Recent site inspections indicated that portions of the rubble-mound stone sectfons of the structures show localized damage and considerable settlement. The structures are considered in fair condition, and no repairs are planned in the near future. An aerial photo of the Lorain Harbor structures is shown in Figure 222.

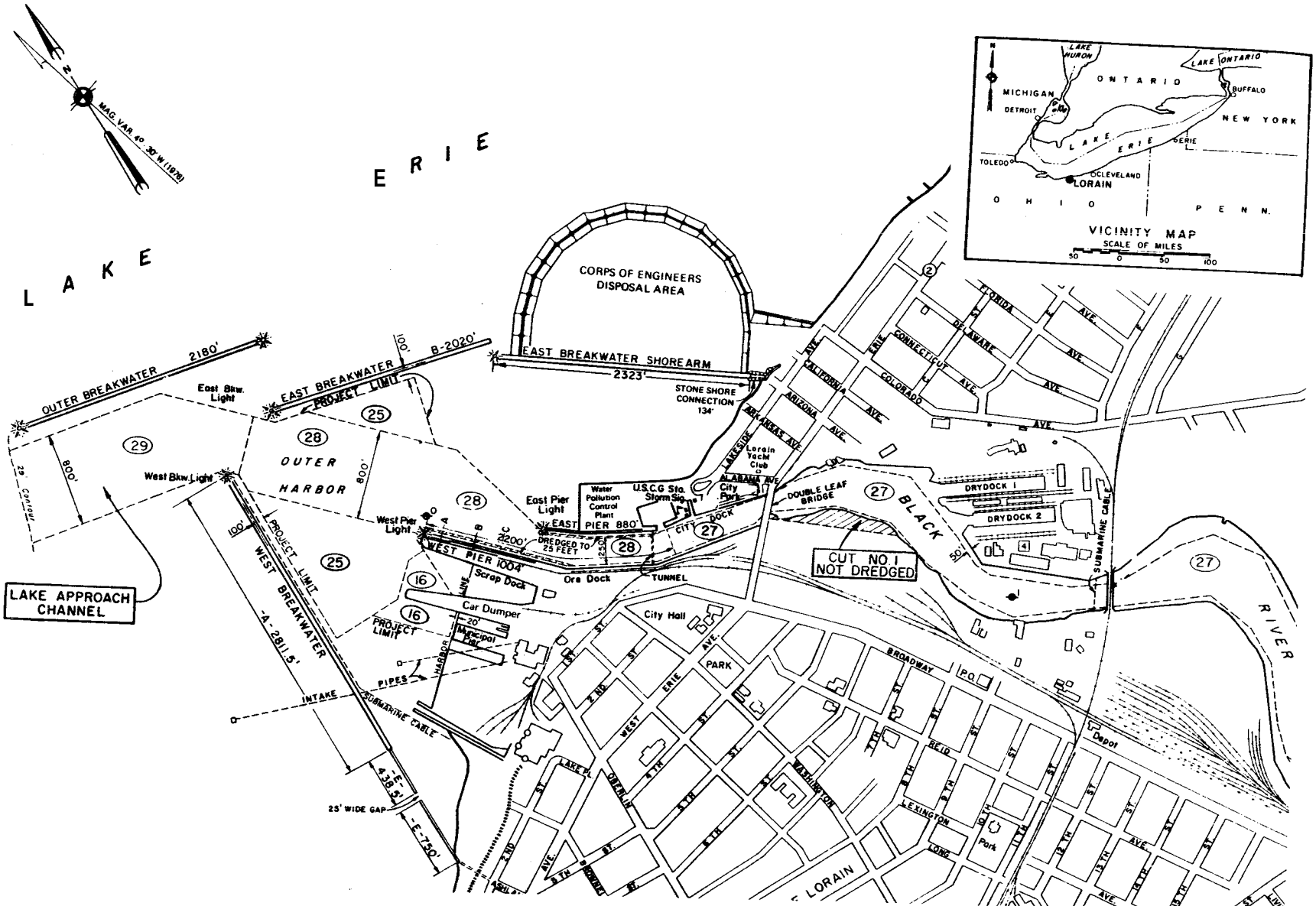
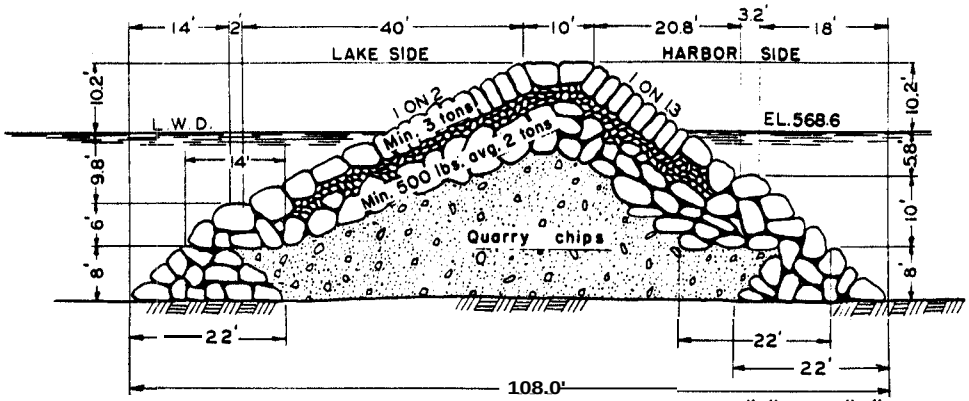
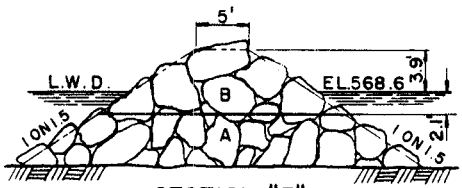


Figure 219. Lorain Harbor, Ohio



SECTION OF EAST AND WEST BREAKWATERS "A" AND "B"
(BUILT 1901-1915)

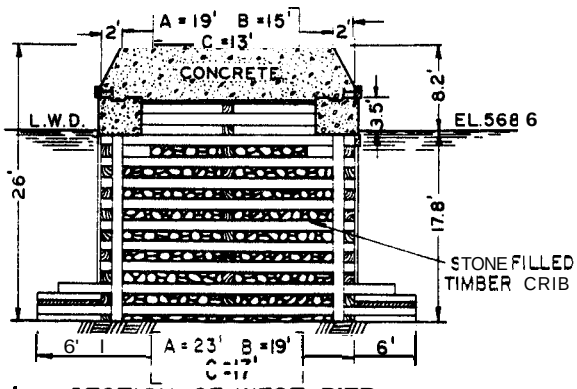
NOTE: OUTER 280' OF EAST BREAKWATER REMOVED IN 1965.



SECTION "E"
WEST BREAKWATER EXTENSION
TO SHORE COMPLETED IN 1921

A - MIN. WEIGHT 500 LBS NOT LESS THAN 50% 2 TONS OR MORE

B - MIN. WEIGHT 2 TONS



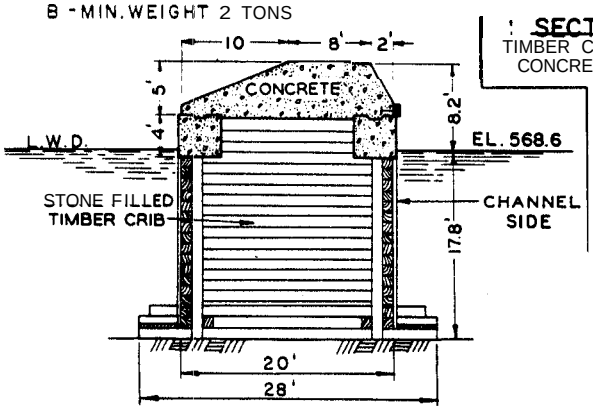
SECTION OF WEST PIER
TIMBER CRIB STRUCTURE BUILT, 1828-1896
CONCRETE SUPERSTRUCTURE, 1897-1908

SECTION A - PIERHEAD TO A POINT 244' SHOREWARD

SECTION B - NEXT 365'

SECTION C - NEXT 395' TO END OF PIER

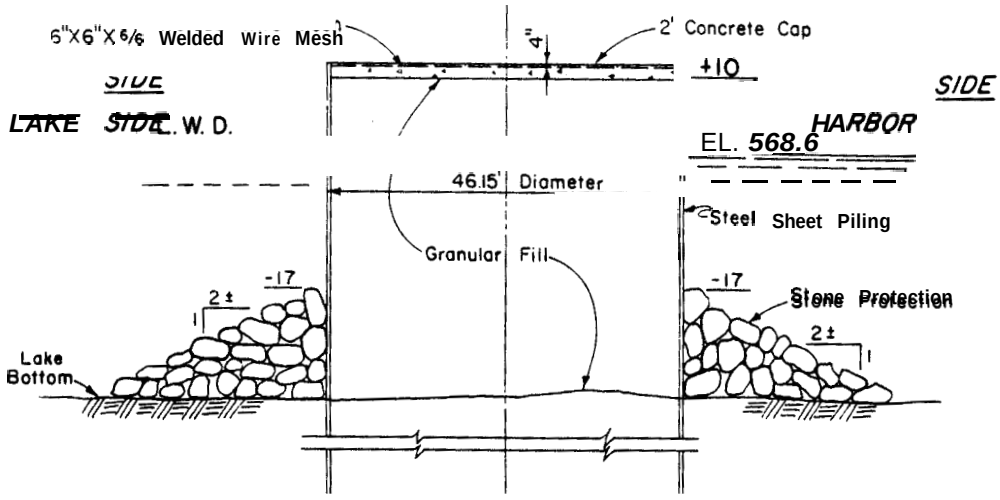
TOTAL LENGTH 1004'



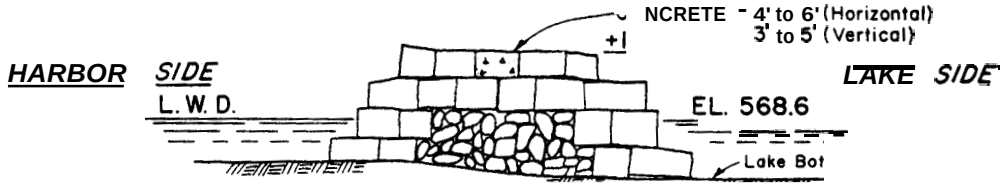
SECTION OF EAST PIER
TIMBER CRIB:
SUB-AND SUPERSTRUCTURE, 1830-1894;
CONCRETE SUPERSTRUCTURE, 1903-1905;

NOTE: 995' OF OUTER END OF PIER REMOVED IN 1965; TOTAL OVERALL LENGTH AFTER REMOVAL IS 880 .

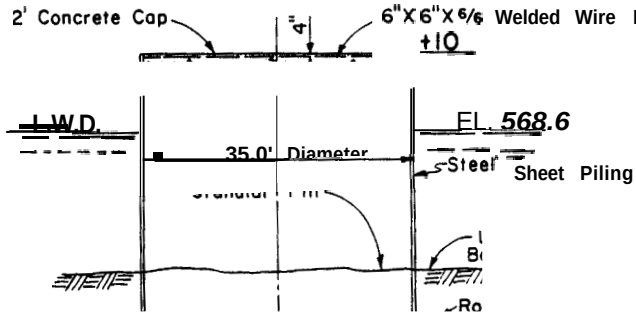
Figure 220. Typical pier and breakwater cross sections, Lorain Harbor, Ohio



TYPICAL SECTION
OUTER BREAKWATER
(BUILT 1964-1965)



TYPICAL SECTION OF
RUBBLE MOUND SHORE CONNECTION
EAST BREAKWATER SHORE ARM
(BUILT 1963)



TYPICAL SECTION OF CELL
EAST BREAKWATER SHORE ARM
(BUILT 1963)

Figure 221. Typical breakwater cross sections, Lorain Harbor, Ohio

Figure 222. Aerial view of Lorain Harbor, Ohio

Table 84

Rocky River Harbor East Pier

Rocky River, Ohio

Date(s)	Construction and Rehabilitation History
1873	Construction of a 448-ft-long rubble-mound pier (Figure *223*, Section B) was completed east of the mouth of the Rocky River. The crest el of the pier was +5.0 ft (Figure *224*, Section B).
1941	The existing pier was rebuilt to its original design and extended an additional *452* ft lakeward (Figure *223*, Section A). The pier extension was of rubble-mound construction and had a crest width of 5 ft and a crest el of +5 ft lwd (Figure *224*, Section A). Side slopes were 1V:1.3H, and armor stones had a minimum weight of *2.5* tons with not less than 40 percent of 4 tons or more.
1970	A total of 260 stones was placed on the pier to repair storm damage.
1981	An inspection of the pier indicated the lakeward portion was in good condition, but the shoreward 390 ft of the pier required rehabilitation. Although no emergency existed at this rime, maintenance was recommended to provide full protection to the river entrance and safer access for fishermen onto the pier. It is not known if the repairs were performed. An aerial view of the Rocky River Harbor East pier is shown in Figure 225.

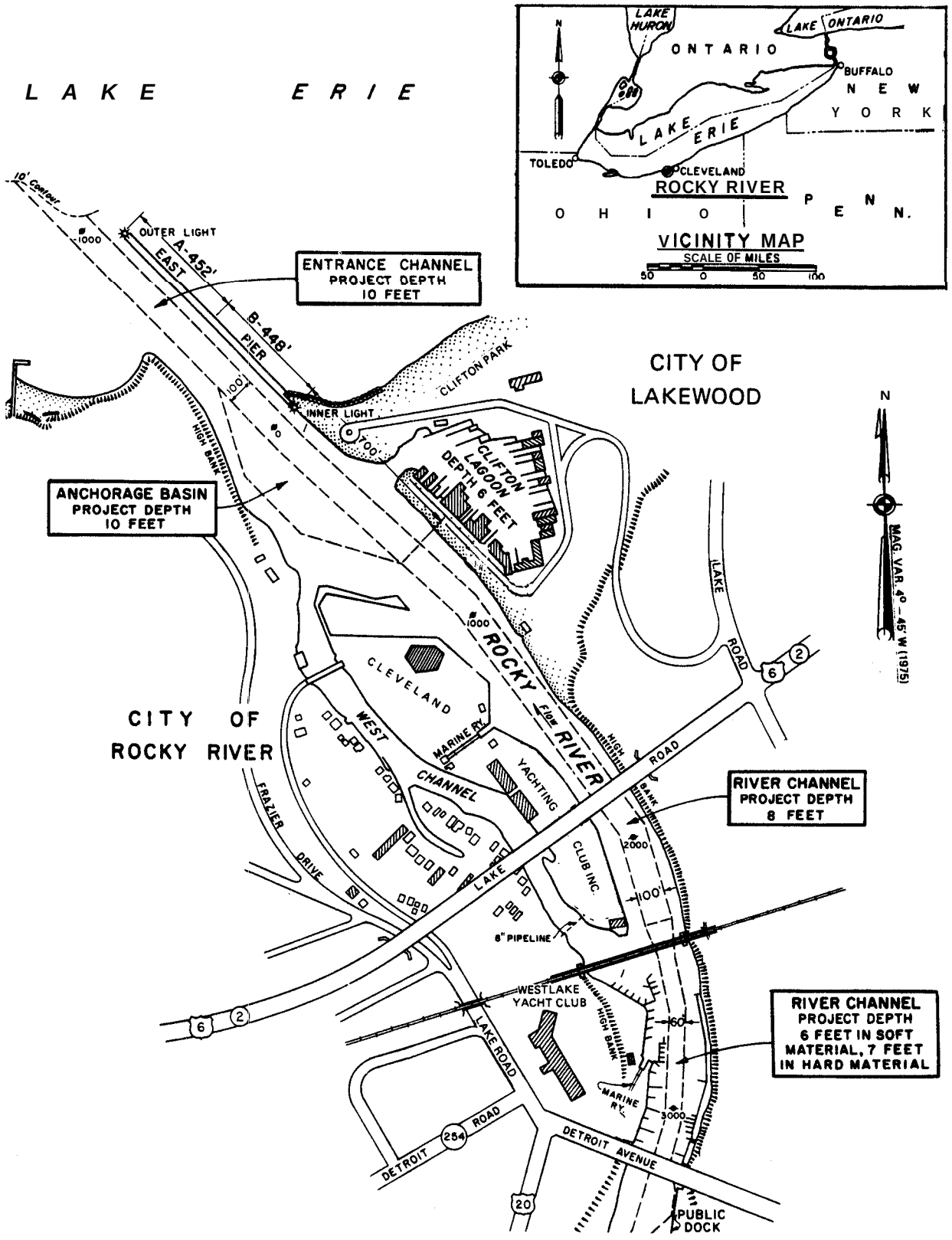
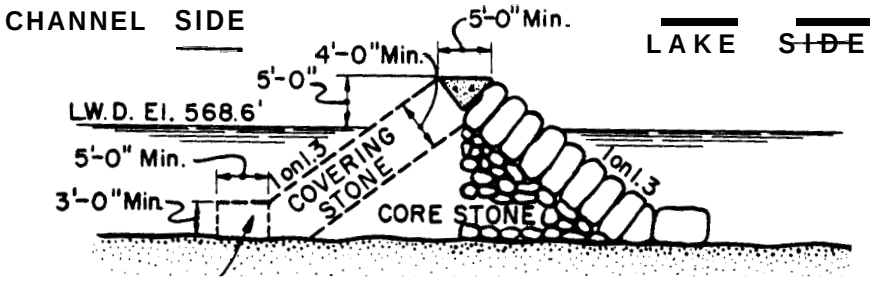


Figure 223. Rocky River Harbor, Ohio



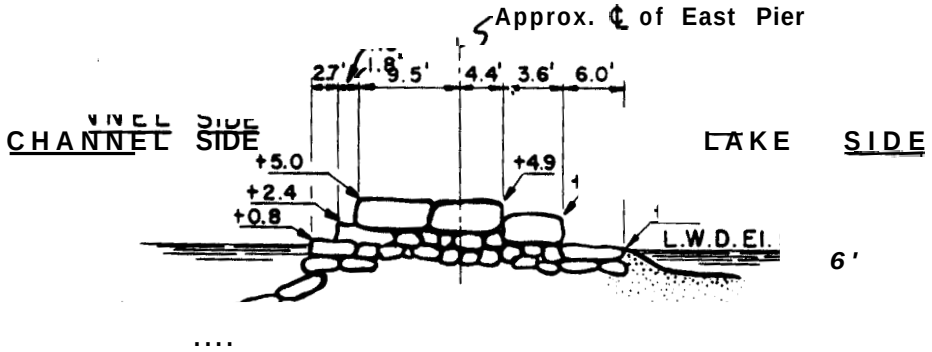
SECTION OF EAST PIER -A-

(LAKEWARD 452 FT. BUILT 1941)

Covering Stone - Minimum weight 2½ tons, not less than 40% 4 tons or more.

Toe Stone - Minimum weight 6 tons.

Core Stone - Not less than 75% 150 pounds or more, not more than 5% less than 5 pounds each.



SECTION OF EAST PIER -B-

(INNER 448 FT. BUILT 1873, REBUILT 1941)

Figure *224.* **Typical pier cross sections, Rocky River Harbor, Ohio**

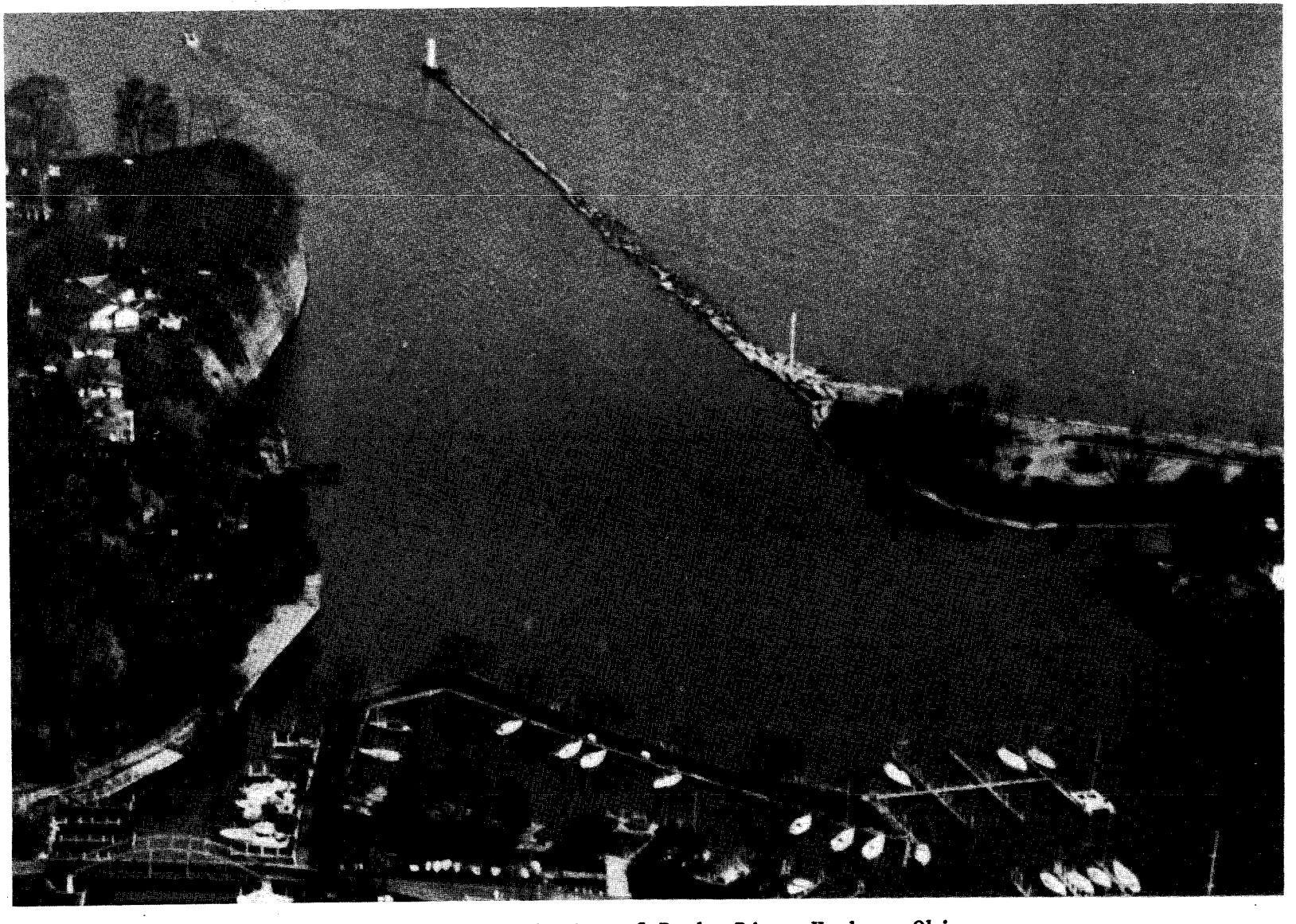


Figure 225. Aerial view of Rocky River Harbor, Ohio

Table 85

Cleveland Harbor Structures

Cleveland, Ohio

Date(s)	Construction and Rehabilitation History
1875	Construction of a 1,602-ft-long stone-filled timber crib east pier at the mouth of the Cuyahoga River (Figure 226) was completed. (Figures 226, 227, 228, and 229 illustrate structures at Cleveland Harbor.) The pier was 20 ft wide and included a concrete superstructure with a crest el of +7.3 ft lwd (Figure 227).
1876-1884	Construction of a 6,048-ft-long stone-filled timber crib west breakwater (Figure 226) was completed. The structure was 32 ft wide, and riprap stone was placed on the lakeside to an el of +5 ft lwd.
1887-1900	Construction of a 3,000-ft-long portion of the east breakwater (Figure 226, Sections X and Y) was completed. The structures were stone-filled timber cribs that were 32 ft wide.
1898-1907	A concrete superstructure was installed on the west breakwater to a crest el of +12 ft lwd.
1899-1901	Construction of a 1,440-ft-long west pier was completed (Figure 226). It was a stone-filled timber crib structure with a concrete superstructure (Figure 227) installed at an el of +6.8 ft lwd.
1903-1915	Construction of a 17,970-ft-long portion of the east breakwater was completed (Figure 226, Sections P and D). The breakwater was a rubble-mound structure with a crest el of +10.3 ft lwd and a crest width of 10 ft (Figure 227, Section P, Figure 229, Section D). Side slopes were 1V:1.5H.
1904-1909	Construction of the east and west arrowhead breakwaters was completed (Figure 226) at the main entrance. These structures were each 1,250 ft long and constructed of rubble-mound materials. They had crest widths of 10 ft and an el of +8 ft lwd (Figure 227). Side slopes of the arrowheads along the water level were 1V:1.3H. Armor stone had a minimum weight of 3 tons, with not less than 50 percent of 5 tons or more.
1917-1926	A stone superstructure was installed on portions of the east breakwater (Figure 226, Sections X and Y). The crest el of Section X (Figure 228) was +6 ft lwd. Riprap was also installed along both sides of this portion of the breakwater. The crest el of Section Y (Figure 228) was +10 ft lwd, and stone extended from the el down the lakeside of the structure to the lake bottom.
1961-1962	Rehabilitation of 1,700 ft of the east breakwater (Figures 226 and 227, Section P) was performed. Original construction methods were used in making the repairs.

(Continued)

Table 85 (Concluded)

Date(s)	Construction and Rehabilitation History
1963	Rehabilitation of 1,000 ft of the protective riprap slope on the lakeside of the west breakwater (Figures 226 and 227) was performed.
1979	Portions of the west breakwater were rehabilitated (Figure 229). The concrete cap was restored to its original height, and new armor stone was installed along the lakeside of the riprap slope. The eastern portion of the east breakwater was in poor condition during a site inspection.
1980	Rehabilitation of 4,400 ft of the eastern end of the east breakwater (Figure 226, Section D) was performed using 29,700 two-ton unreinforced dolos concrete armor units. Two layers of dolosse were placed on the lakeside of the trunk and around the head using a placement density of 1.61 dolosse per 25 lin ft of breakwater. The slope was 1V:2H. Model tests were not conducted prior to installation of the dolosse.
1982	Repair of the head of the east breakwater following a storm in April was completed using 200 two-ton unreinforced dolosse.
1982-1983	Model tests were conducted to determine the breakwater modifications necessary at the west (main) entrance to accommodate the passage of 1,000-ft-long ore carriers (Bottin 1983). Breakwater modifications at Edgewater Marina (adjacent to the west breakwater) for wave protection also was investigated in the model (Bottin and Acuff 1983).
1984	An inspection of the east breakwater (Figure 226, Section D) revealed 659 broken dolosse. Many of these units were broken during initial placement. A concentration of broken dolosse near the top of the slope at the head was believed to be remnants of those broken during the 1982 storm. In general, dolosse are generally confined to the upper third of the structure slope and are at about 2 percent of the total number placed.
1985	A contract was awarded to rehabilitate an additional 3,300 ft of the east breakwater (an area of Section P (Figure 226) adjacent to the dolos rehabilitation). The repairs involved placement of 9- to 20-ton armor-stone mix. Model testing was conducted prior to rehabilitation work (Markle and Dubose 1985).
1986	Repairs have been extensive at Cleveland Harbor over its lifetime (particularly to the east breakwater). Until recently the structure was repaired in a manner similar to the original construction using 3- to 8-ton stone. Consequently, maintenance on the breakwater during a 19-year period (1966-1984) involved repairs to about 12,500 lin ft of breakwater at an expenditure in excess of $17,000,000. Since the latest rehabilitation, the structures are considered to be in good condition. Aerial photos showing the Cleveland Harbor structures are presented in Figures 230-233.

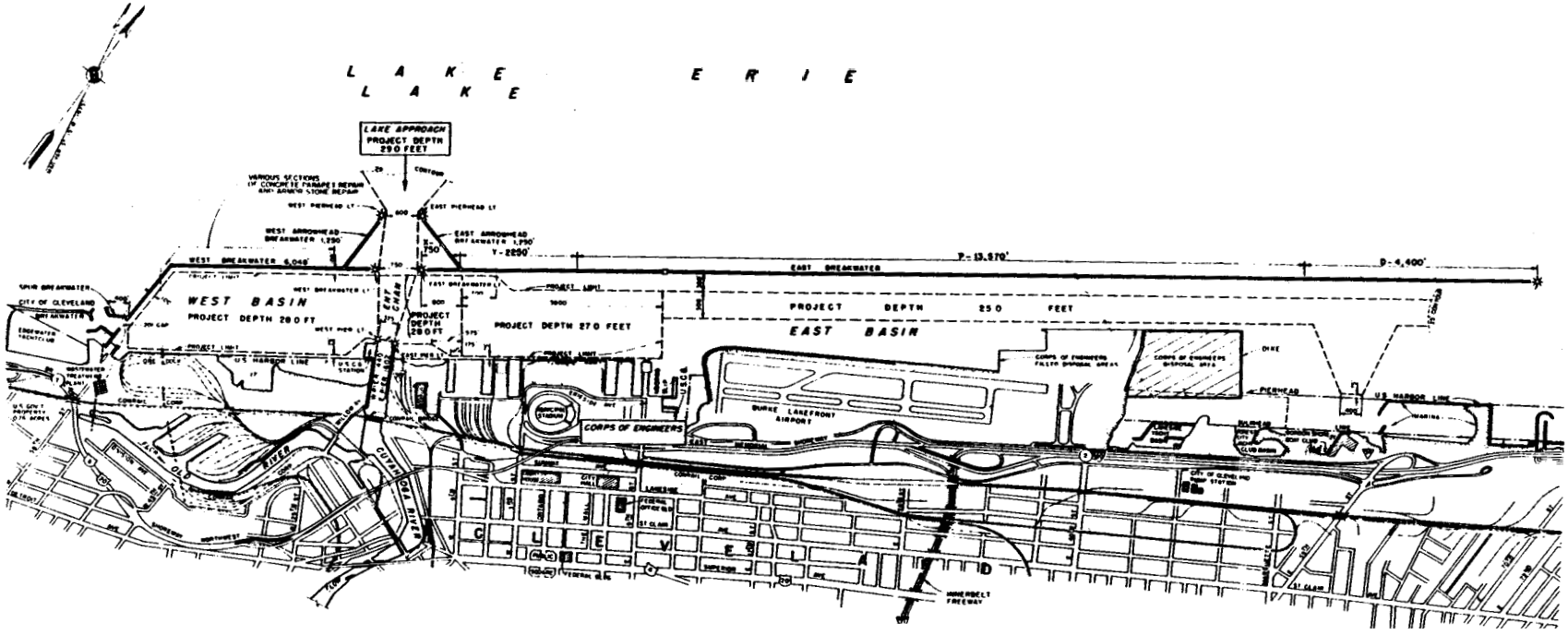
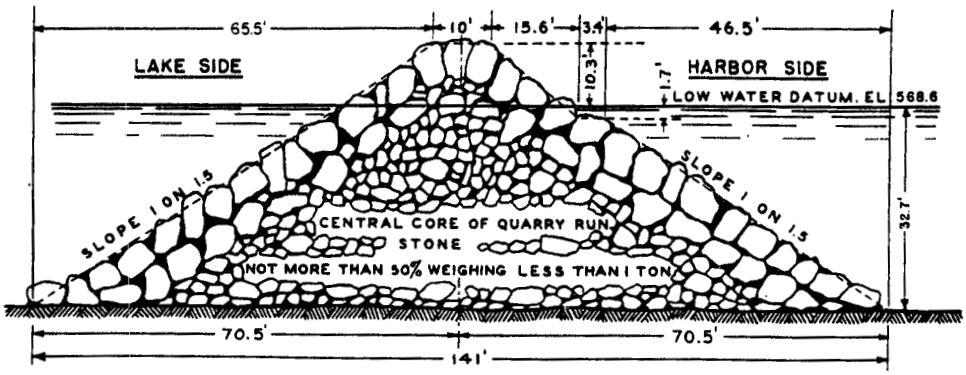


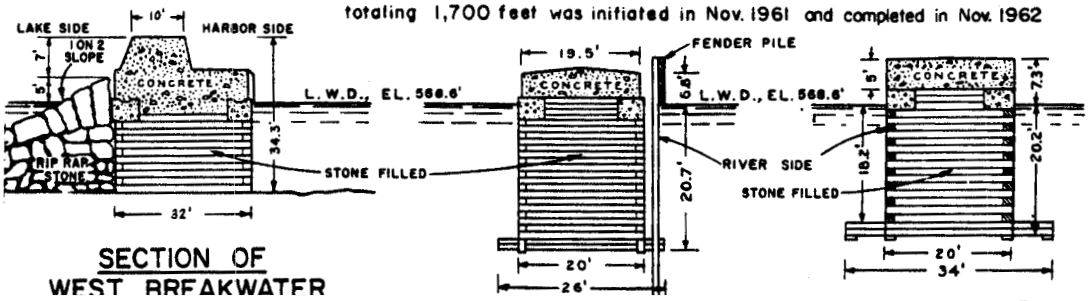
Figure 226. Cleveland Harbor, Ohio



SECTION OF EAST BREAKWATER -P-

(BUILT 1903-1915)

Rehabilitation of breakwater in 5 sections totaling 1,700 feet was initiated in Nov. 1961 and completed in Nov. 1962



SECTION OF WEST BREAKWATER

(BUILT 1876-1884)

CONCRETE SUPER-STRUCTURE BUILT 1898-1907

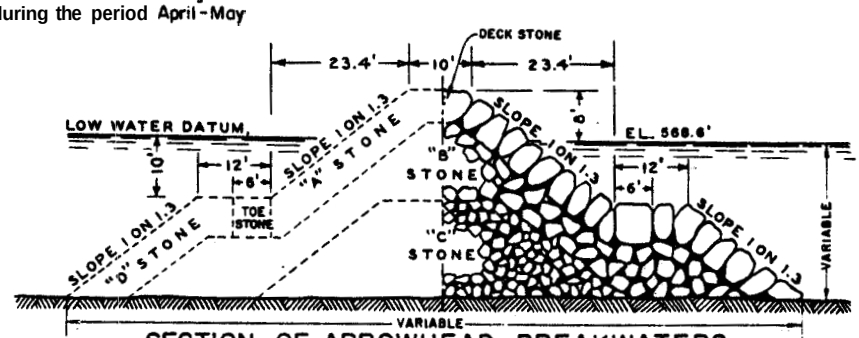
Rehabilitation of protective riprap slope on lake side, *in* sections totaling 1000' was done during the period April-May 1963.

SECTION OF WEST PIER

(BUILT: SUB-STRUCTURE 1899 SUPER-STRUCTURE 1901)

SECTION OF EAST PIER

(BUILT 1875)

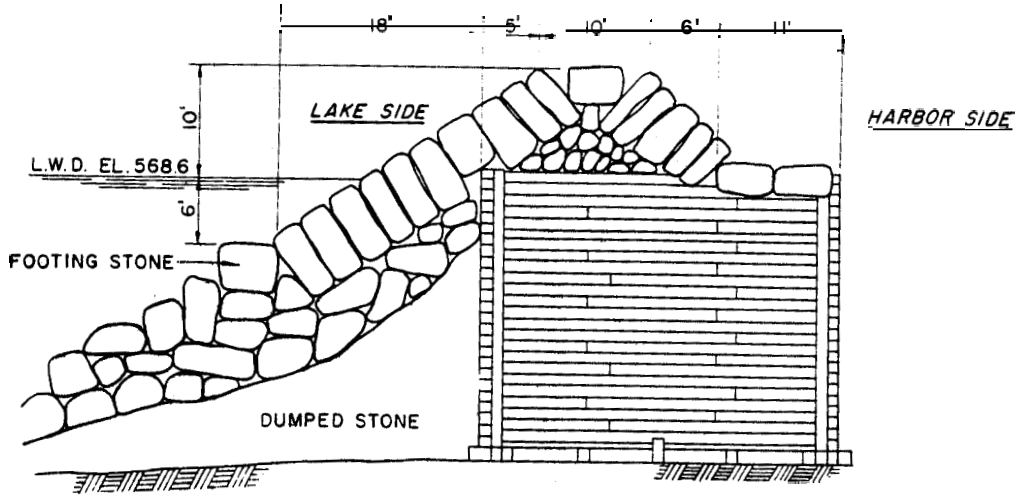


SECTION OF ARROWHEAD BREAKWATERS

(BUILT 1904-1909)

DCCK STONE–MIN WEIGHT 5 TONS,
A STONE – MIN. WEIGHT 3! TONS, NOT LESS THAN 50% 5 TONS OR MORE.
B STONE – MIN. WEIGHT 100 LIS.
C STONE – NOT LESS THAN 35% 75 LBS OR MORE, NOT MORE THAN 3% LESS THAN 1 LB.
D STONE – MIN. WEIGHT 3 TONS.
TOE STONE – MIN. WEIOHT 7 TONS.

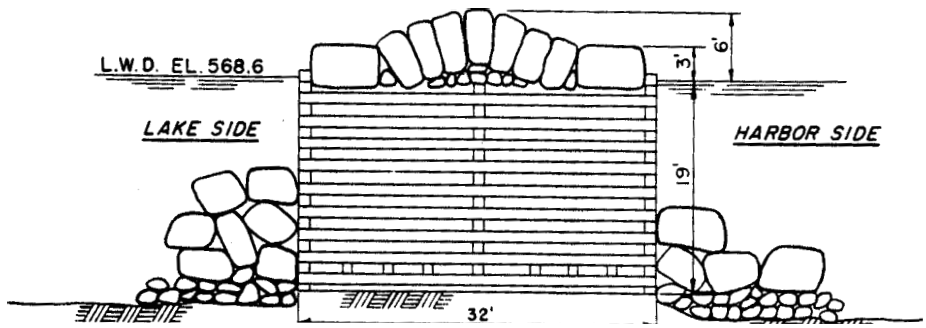
Figure 227. Typical pier and breakwater cross sections, Cleveland Harbor, Ohio



SECTION "Y"

EAST BREAKWATER

(BUILT 1887-1900)
(STONE SUPERSTRUCTURE BUILT 1917-1926)

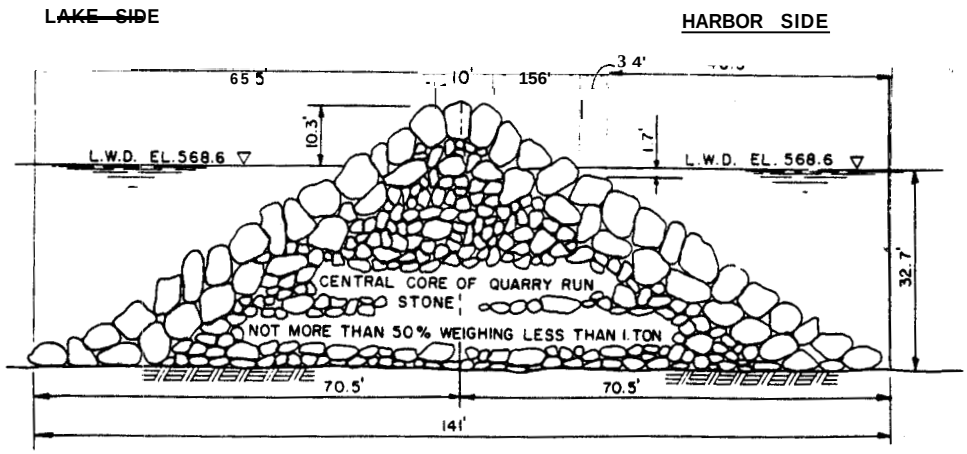


SECTION "X"

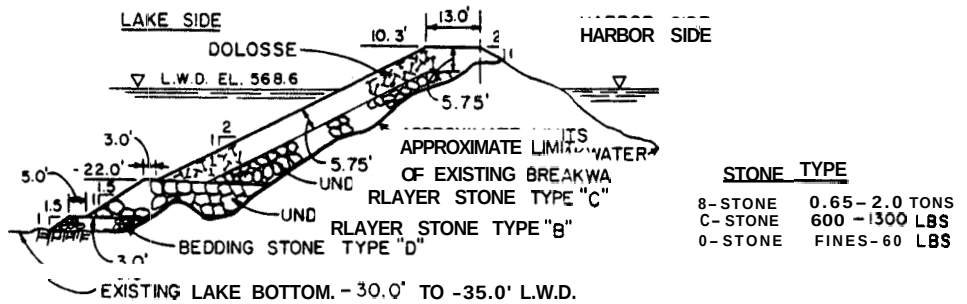
EAST BREAKWATER

(BUILT 1887-1900)
(STONE SUPERSTRUCTURE BUILT 1917-1926)

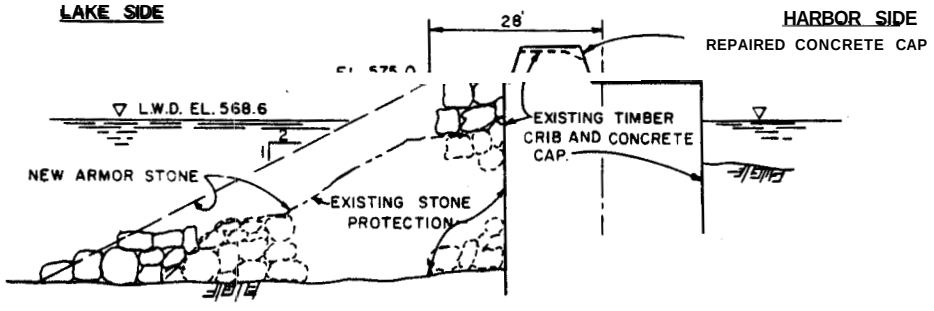
Figure 228. Typical east breakwater cross sections, Cleveland Harbor, Ohio



SECTION OF EAST BREAKWATER - 0-
(AS BUILT 1903-1915)



SECTION OF EAST BREAKWATER-0-
REHABILITATION OF PROTECTIVE CONCRETE ARMOR UNITS ON LAKE SIDE, 4,400 FT. WAS DONE IN 1980



SECTION OF WEST BREAKWATER
REHABILITATION OF PROTECTIVE RIPRAP SLOPE AND CONCRETE CAP
DONE IN 1979.

Figure 229. Typical breakwater cross sections, Cleveland Harbor, Ohio

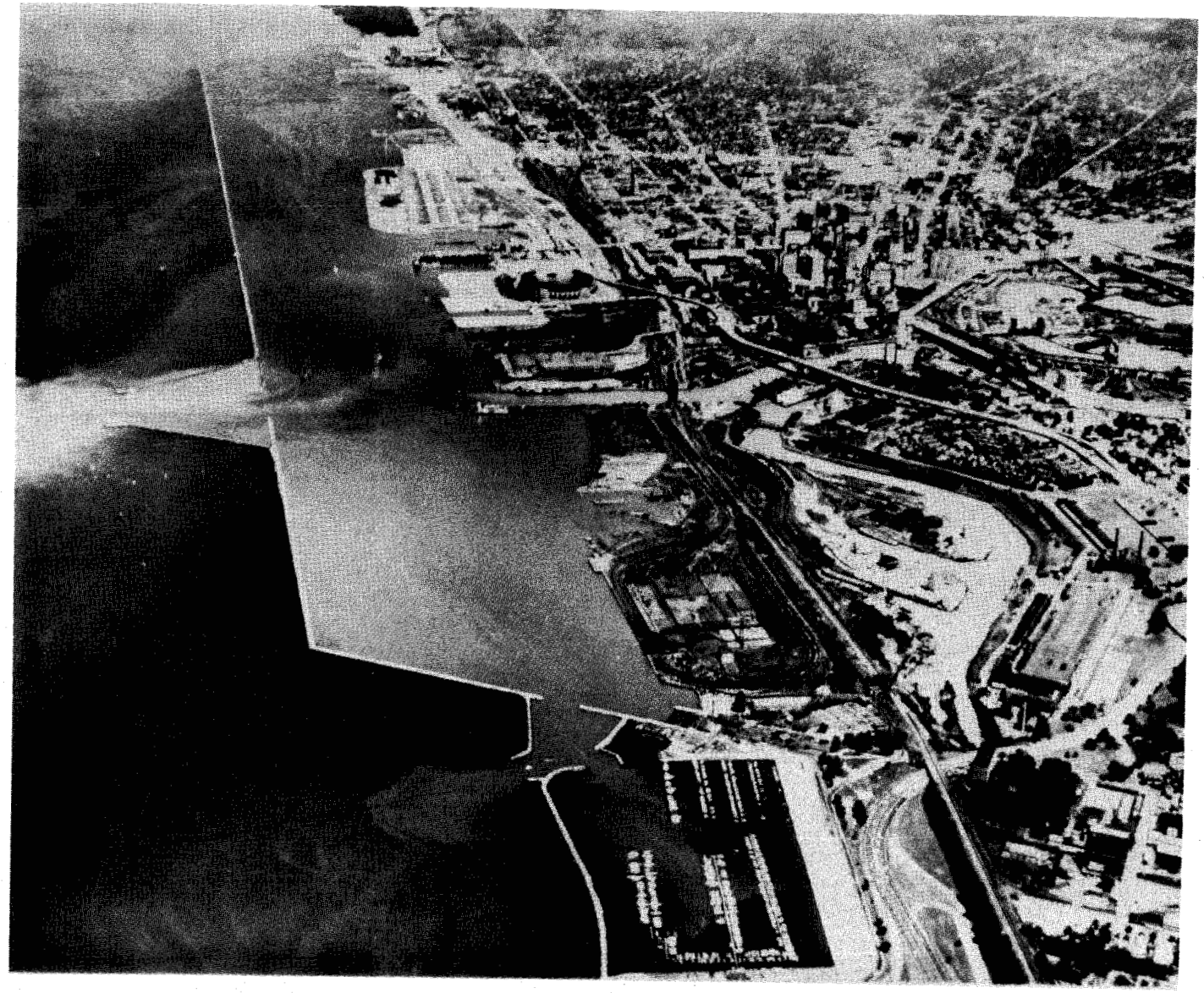


Figure 230. Aerial view of Cleveland Harbor, Ohio

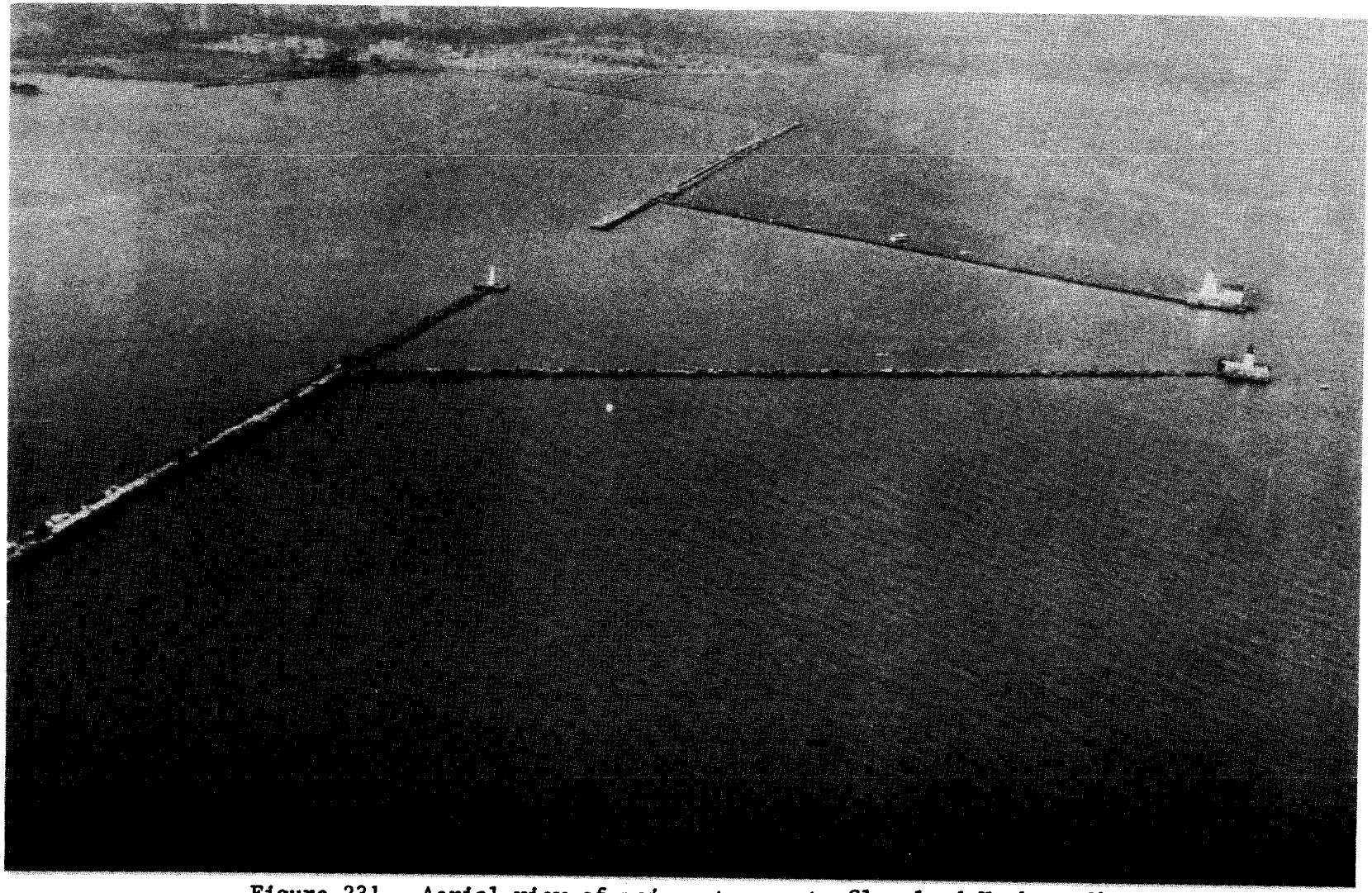


Figure 231. Aerial view of main entrance to Cleveland Harbor, Ohio

Figure 232. Aerial view of Cleveland Harbor, Ohio looking west

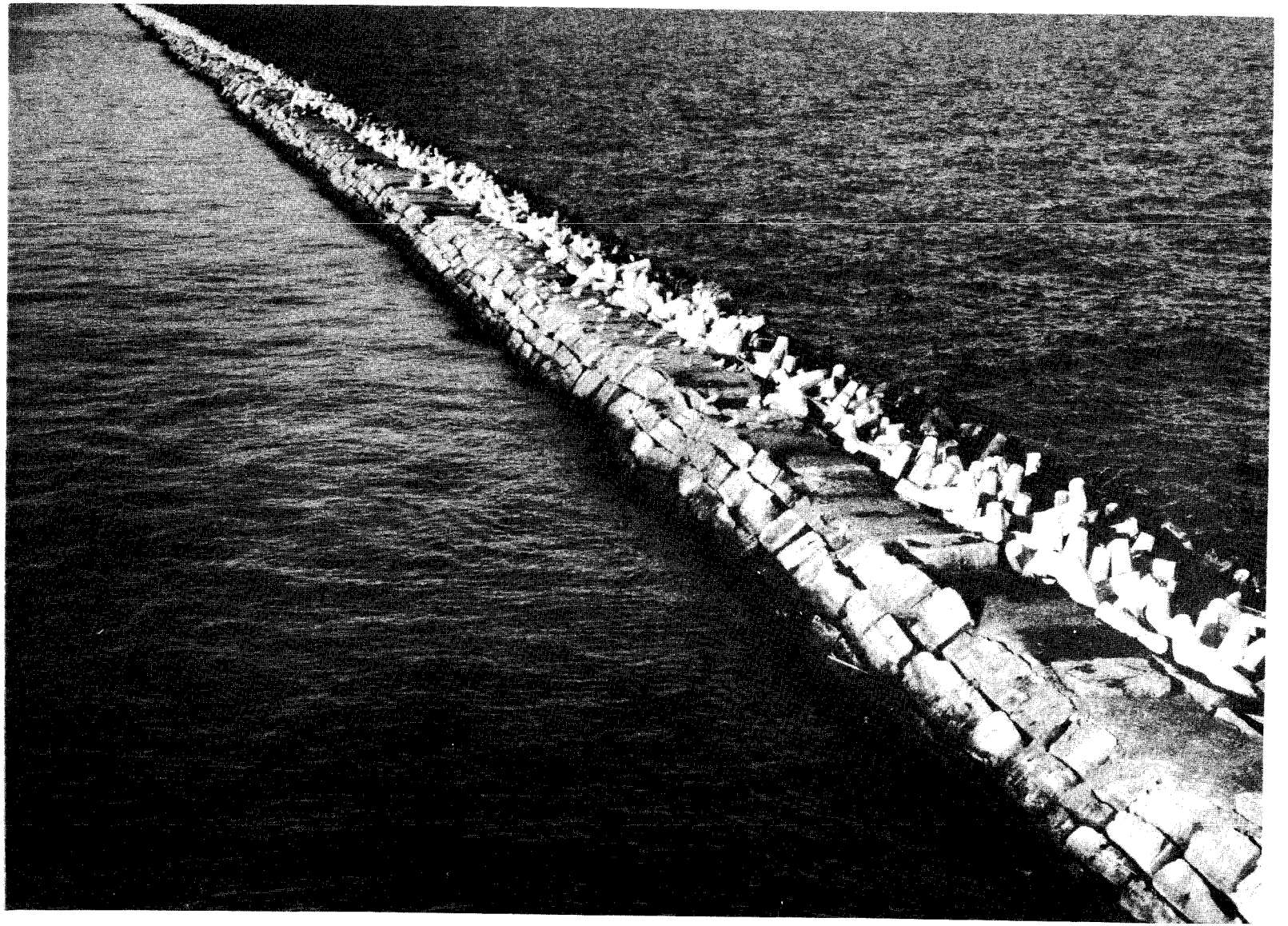


Figure 233. Aerial view of rehabilitated east breakwater, Cleveland Harbor, Ohio

Table 86

Fairport Harbor Structures

Fairport, Ohio

Date(s)	Construction and Rehabilitation History
1868	Construction of the east pier (Figure 234) was completed. The pier was a stone-filled timber crib structure that was 20 ft wide (Figure 235, Section E).
1905	The east pier was capped with a concrete and stone superstructure (Figure 235, Section E). Construction of the shoreward 2,325-ft-long portion of the west breakwater (Figure 234, Sections H and J) was completed. The innermost 1,500-ft portion of the breakwater was of rubble-mound construction (Figure 236, Section H). It had a crest el of +9.9 ft lwd with a width of 10 ft. Side slopes were 1V:2H on the lakeside and 1V:1.3H on the channel side. The lakeward portion of the breakwater was constructed with stone-filled timber cribs (Figure 236, Section J) that were 26 ft wide.
1911	The west breakwater was extended by 1,053 ft (Figure 234, Section A). The extension was of rubble-mound construction and had an el of +10.4 ft lvd with a crest width of 10 ft (Figure 235, Section A). Side slopes were 1V:1.5H, and the armor stones used ranged from 4 to 8 tons each.
1925	Stone was placed over the cap and on the lakeside of the timber crib portion of the west breakwater (Figures 234 and 236, Section J). The stone was placed at an el of +9.9 ft lwd with a crest width of 10 ft and side slopes of 1V:2H.
1932	Construction of a 6,750-ft-long rubble-mound detached east breakwater (Figure 234, Section B) was completed. The breakwater had a crest el of +8.2 ft lwd and a width of 10 ft (Figure 235, Section B). Side slopes were 1V:1.5H and had a minimum weight of 3 tons.
1935	A 500-ft-long extension of the west breakwater (Figure 234, Section F) was completed. The extension consisted of a sand-filled cellular steel sheet-pile structure (Figure 235, Section F). The cells were 30 ft in diameter and capped with concrete at an el of +8.4 ft lwd. Riprap was placed on the channel side.
1939	Construction of a 500-ft-long west pier (Figure 234, Section D) was completed. The pier consisted of sand-filled cellular steel sheet-pile structures (Figure 235, Section D). The cell diameters were 34 ft, and they were capped with concrete at an el of +7.9 ft lwd.
1946	Because of settlement of the sand fill, one of the cells in the west breakwater extension was repaired by using cut stone to replace the concrete cap.

(Continued)

Table 86 (Concluded)

Date(s)	Construction and Rehabilitation History
1949	Because of deterioration of the inner portion of the east pier (Figure 234, Section C) was removed and replaced with steel sheetpiling with a sand fill (Figure 235, Section C). The el of the pier was +8.2 ft lwd.
1972	Settlement of three cell caps in the west breakwater extension led to their replacement with cut stone.
1979	An inspection of the piers and the west breakwater indicated that they were in good to very good condition. Slight settlement of Section J (Figure 234) was noted, however.
1984	Normal maintenance repair of the west breakwater was performed for a cost of $308,000.
1986	The piers and the west breakwater are considered to be in good condition presently. The east breakwater is in a state of deterioration throughout its entire length. At several places the slope stone has disintegrated and settled; and the core stone has washed out, leaving large areas of the structure only slightly above lwd. Since proposed industrial expansion in the lee of the east breakwater never materialized, the structure has not been maintained. An aerial view of the Fairport Harbor structures at the entrance is shown in Figure 237.

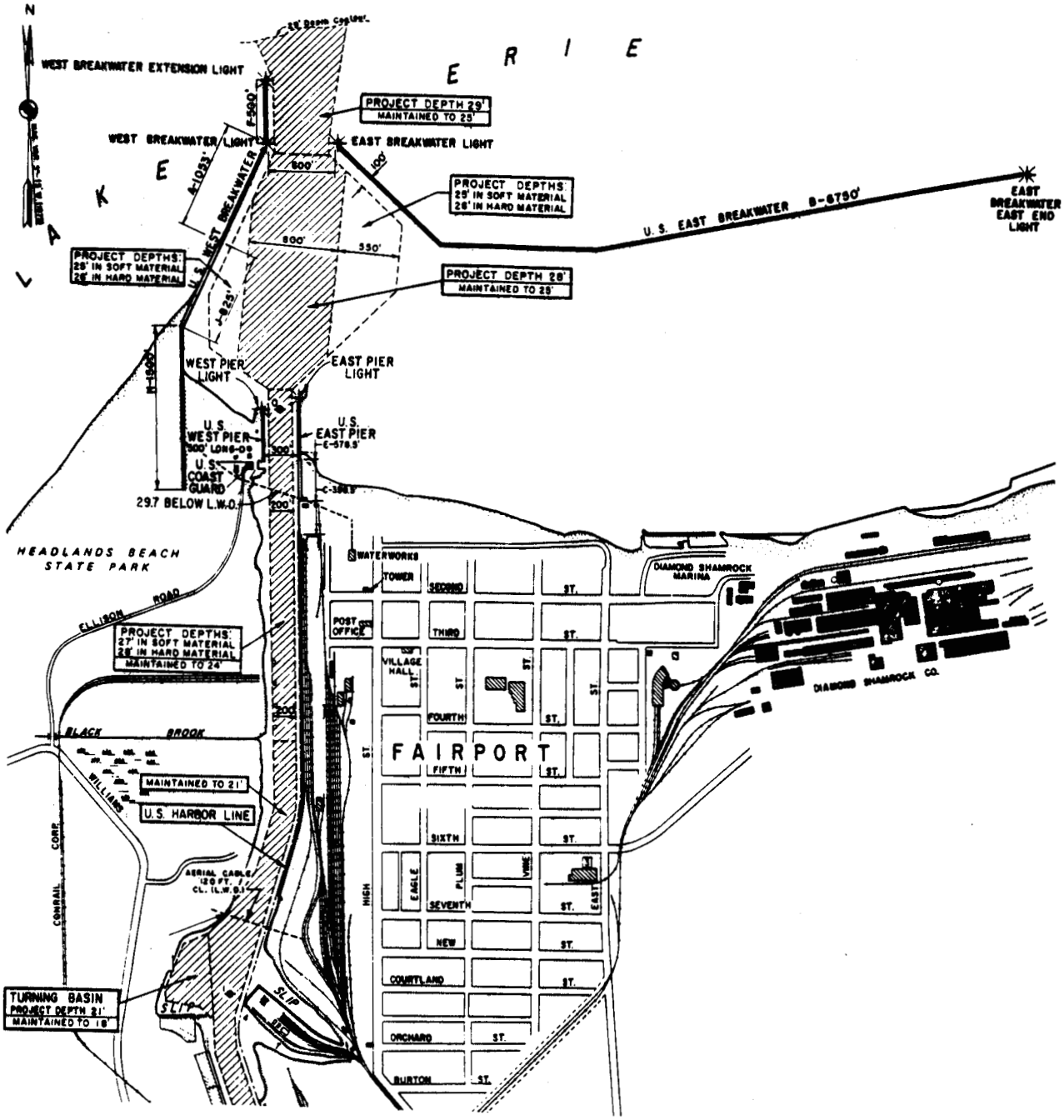
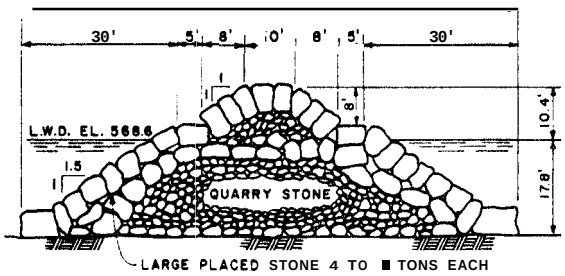
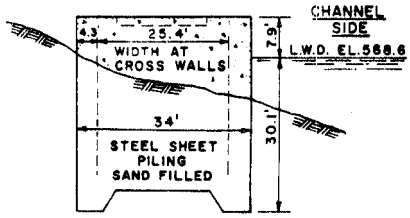


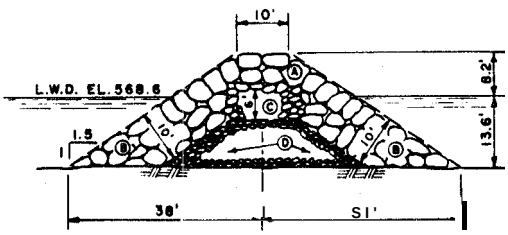
Figure *234*. Fairport Harbor, Ohio



SECTION OF WEST BREAKWATER-A
(BUILT IN 1911)



SECTION OF WEST PIER-D
(BUILT IN 1939)



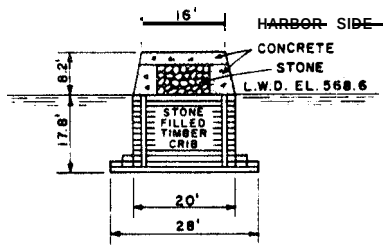
SECTION OF EAST BREAKWATER-B
(BUILT IN 1932)

Ⓐ COVER STONE NOT MORE THAN 10% BY WEIGHT LESS THAN 3 TONS

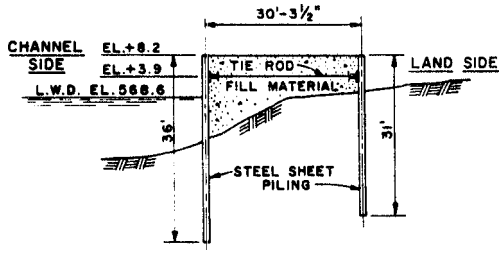
@COVER STONE, MINIMUM WEIGHT 3 TONS

Ⓒ CORE STONE, MINIMUM WEIGHT 500 LBS., SO% BY WEIOHT ONE TON OR OVER.

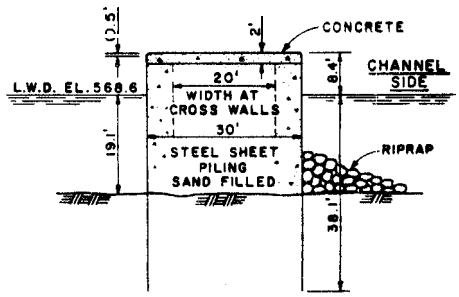
Ⓓ CORE STONE, QUARRY RUN.



SECTION OF EAST PIER-E
(SUB-STRUCTURE BUILT IN 1868
SUPER STRUCTURE BUILT IN 1905)

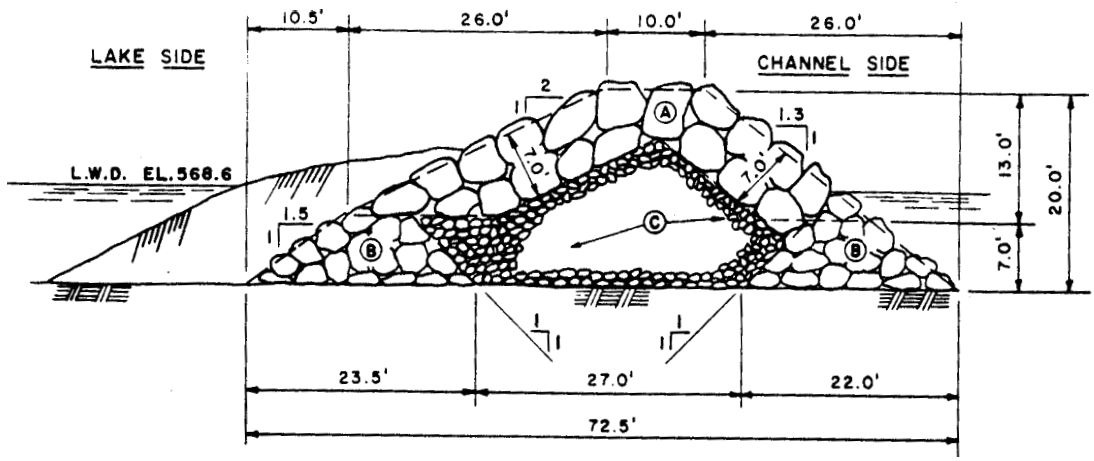


SECTION OF EAST PIER-C
(BUILT IN 1949)



SECTION OF BREAKWATER EXTENSION-F
(BUILT IN 1935)

Figure 235. Typical pier and breakwater cross sections, Fairport Harbor, Ohio

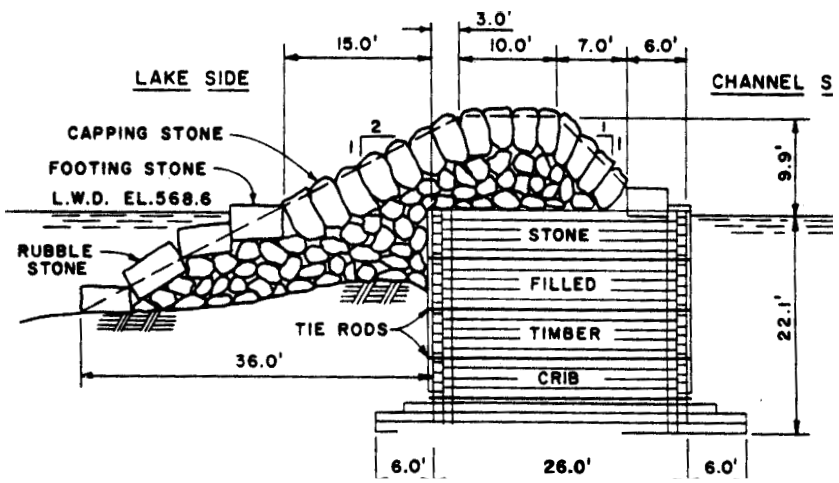


SECTION OF
WEST BREAKWATER-H
(BUILT IN 1905)

Ⓐ COVER STONE-SIZE=19 TONS PER LIN. FT.

Ⓑ QUARRY STONE-SIZE=4 TONS PER LIN. FT.

Ⓒ SMALL RIPRAP STONE-SIZE=18 TONS PER LIN. FT.



SECTION OF
WEST BREAKWATER-J
(BUILT 1905)
(REPAIRED 1925)

Figure 236. Typical west breakwater cross sections, Fairport Harbor, Ohio

Figure 237. Aerial view of Fairport Harbor, Ohio

Table 87

Geneva-on-the-Lake Structure

Geneva-on-the Lake, Ohio

Date(s)	Construction and Rehabilitation History
1978	Construction of three offshore experimental breakwaters was completed as part of a shoreline erosion control demonstration program. These were low-cost shore erosion protection devices which might be feasible for use by private property owners. Three structure designs (i.e., sta-pod, gabion, and z-wall) were constructed for a cost of $167,200. The structures are being monitored, and no maintenance will be performed,
1986	Construction of a small-boat harbor is proposed adjacent to the state park. Two breakwaters totaling about *1,450* ft In length are proposed for harbor protection (Figure 238). Construction **has** not been initiated. The project was model tested (Bottin 1982b).

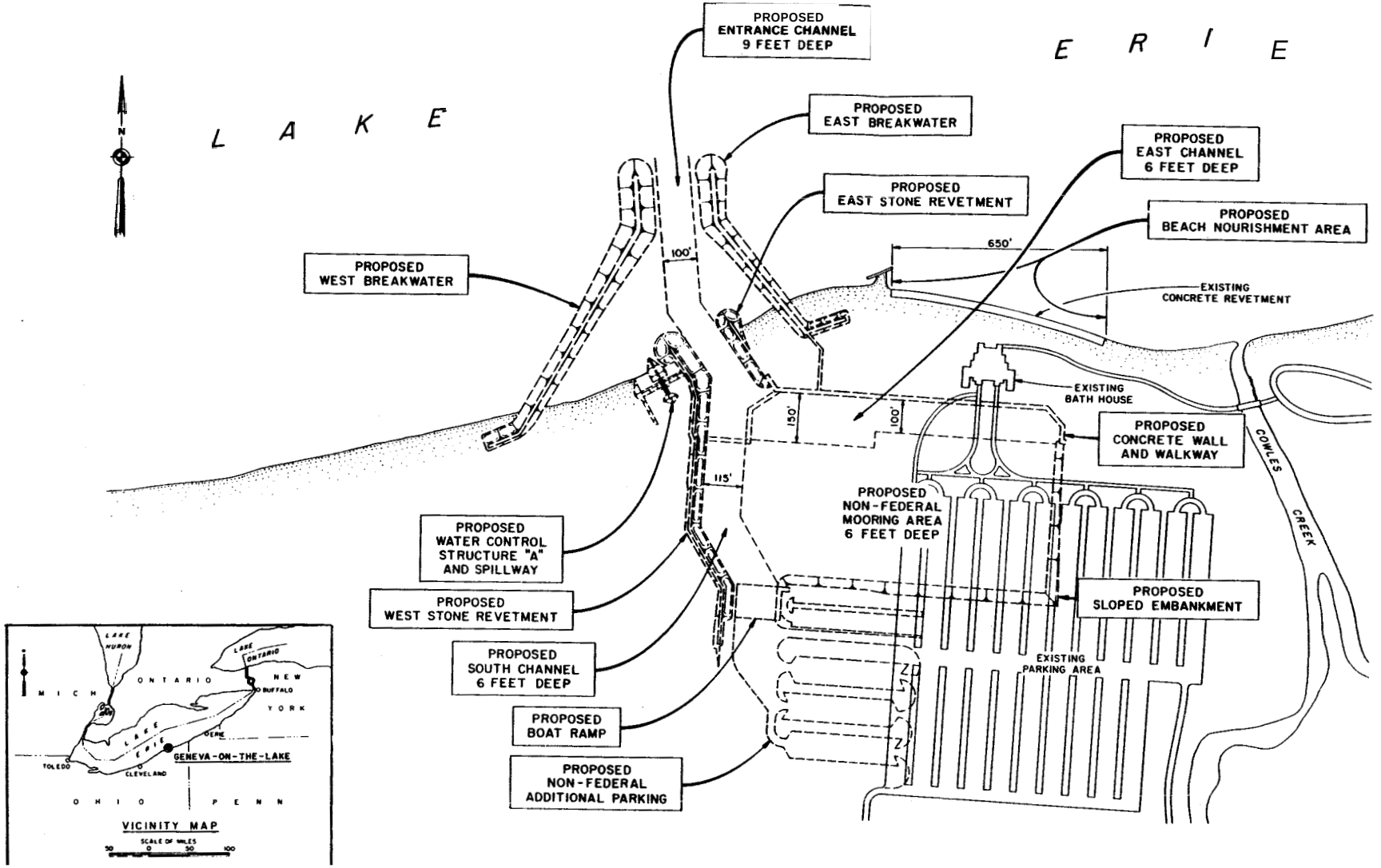


Figure 238. Geneva-on-the-Lake, Ohio

Table 88

Ashtabula Harbor Breakwaters

Ashtabula, Ohio

Date(s)	Construction and Rehabilitation History
1897-1924	Construction of a 6,600-ft-long rubble-mound west breakwater (Figure 239, Sections N and O) was performed during this time. The breakwater had a +10.3 ft crest el lwd and a 10-ft-wide crest (Figure 240, Sections N and O). Side slopes were 1V:1.5H on the lakeside and 1V:1.3H on the harbor side. Armor stone was greater than 3 tons in weight. A 430-ft-long portion of the rubble- mound breakwater was built adjacent to an existing timber crib structure (Figure 239).
1901-1909	The 1,298-ft-long eastern portion of the inner breakwater (Figure 239, Section S) was constructed during this period. The breakwater was a rubble-mound structure with a crest width of 10 ft and an el of +10.3 ft lwd (Figure 241, Section S). Side slopes on the lakeside were 1V:2.5H and 1V:0.75H on the shoreward side. Cover stone with a 3-ft thickness was used.
1912-1915	Construction of a 3,692-ft-long rubble-mound east breakwater (Figure 239, Section P) was completed during this period. The breakwater cross-section was similar to that of the west breakwater built from 1897-1924 (Figure 240, Section P).
1934-1936	Lakeward extensions of the east and west breakwaters (Figure 239, Sections R and Q) were completed, These were rubble-mound extensions with crest els of +10 ft lwd and crest widths of 10 ft (Figure 240, Sections Q and R). Side slopes were 1V:1.3H. Armor stone had a minimum weight of 3 tons with not less than 50 percent of 5 tons or more.
1977	A 100-ft-long, rubble-mound westward extension of the inner breakwater was completed. The extended head section (Figure 241, Section S) had a crest width of 27 ft with a +10 ft lwd el. Side slopes were 1V:1.5H, and cover stones ranged from 3.25 (min) to 7.25 tons (max).
1981-1982	Major rehabilitation of the east and west breakwater trunks (Figure 239) and the western head of the east breakwater was completed. The east breakwater head rehabilitation (Figure 242) involved a 51-ft-wide crest width with an el of +10.3 ft lwd and side slopes of 1V:2H. Armor stone ranging from 9.5 to 19 tons was used. The trunk section of the east breakwater was repaired by the addition of armor stone ranging from 3.7 to 15 tons (Figure 241). The crest was 13 ft wide and had an el of +10.3 ft lwd. The west breakwater rehabilitation (Figure 242) consisted of armor stone (7 to 19 tons) placement on the lakeside to an el of +10.3 ft and a width of 17 ft. Side slopes used on the trunk sections were 1V:1.5H.

(Continued)

Table 88 (Concluded)

Date(s)	Construction and Rehabilitation History
1985	The breakwaters are presently considered to be in good condition; however, some sections of the east breakwater exhibit minor localized damage. An aerial view of the Ashtabula Harbor breakwaters is shown in Figure *243*.

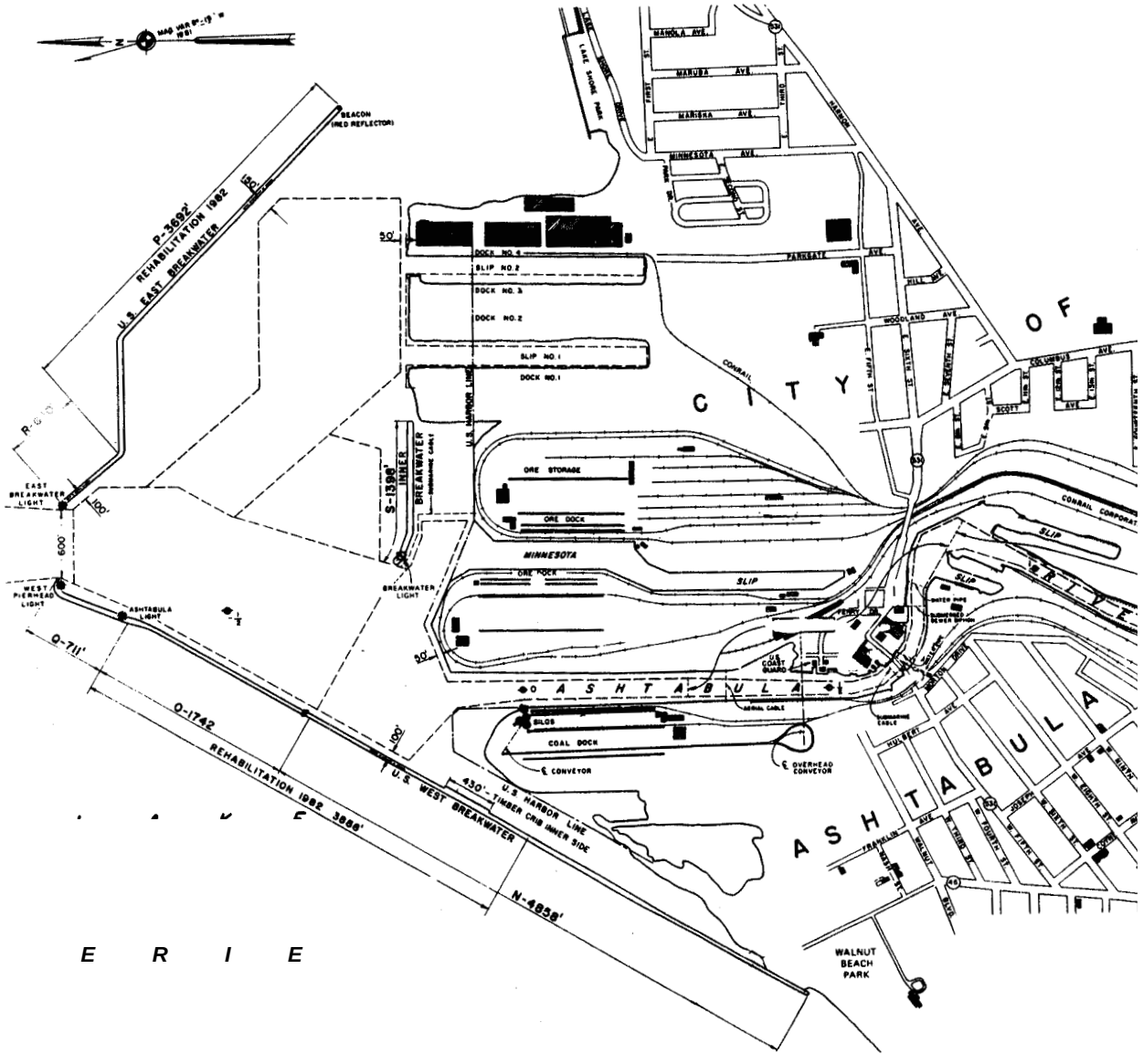
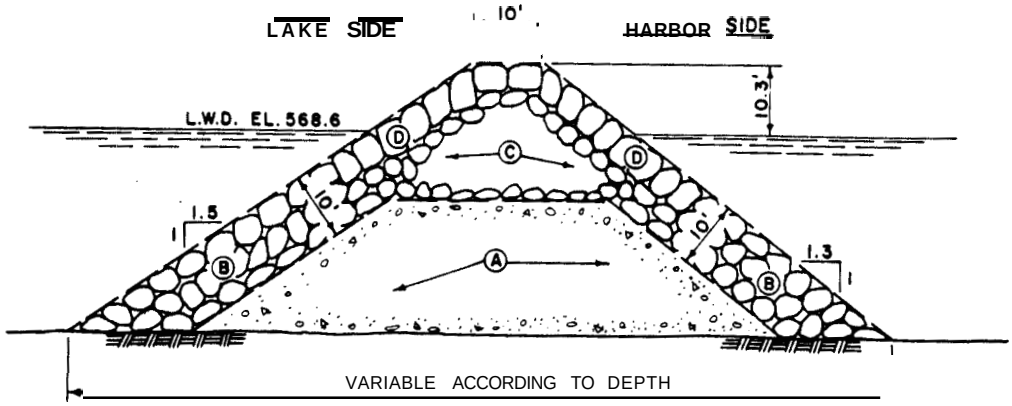


Figure 239. Ashtabula Harbor, Ohio

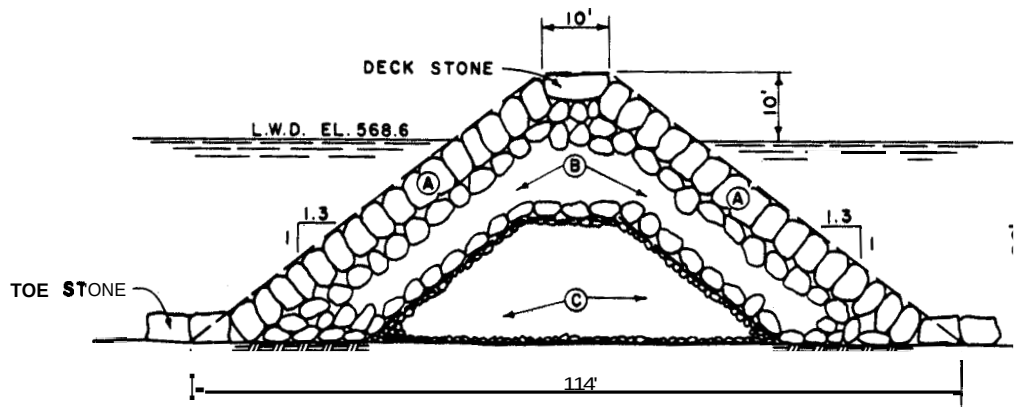


SECTION OF EAST AND WEST BREAKWATERS-N-O-P

TIMBER CRIB IN SECTION-N

(EAST BREAKWATER BUILT 1912-1915
WEST BREAKWATER BUILT 1897-1924)

(A) QUARRY CHIPS.
(B) QUARRY RUN NOT LESS THAN 3 TONS.
(C) QUARRY RUN BETWEEN 500 LBS. AND 3 TONS.
(D) CAPPING STONE GREATER THAN 3 TONS.



SECTION OF BREAKWATERS-Q-R

(BUILT 1934-1936)

DECK STONE: MINIMUM WEIGHT 5 TONS. MINIMUM THICKNESS 30 INCHES.

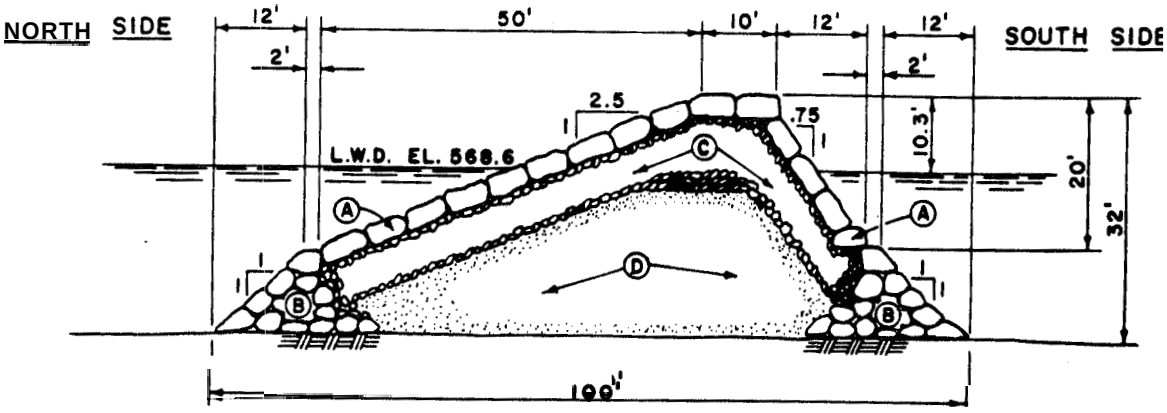
(A) STONE: MINIMUM WEIGHT 3 TONS. NOT LESS THAN 50% 5 TONS OR MORE. MINIMUM THICKNESS 24 INCHES.

(B) STONE: MINIMUM WEIGHT 150 LBS.

(C) CORE STONE; NOT LESS THAN 35% 75 LBS. NOT MORE THAN 3% WEIGHING LESS THAN 1 LB. EACH.

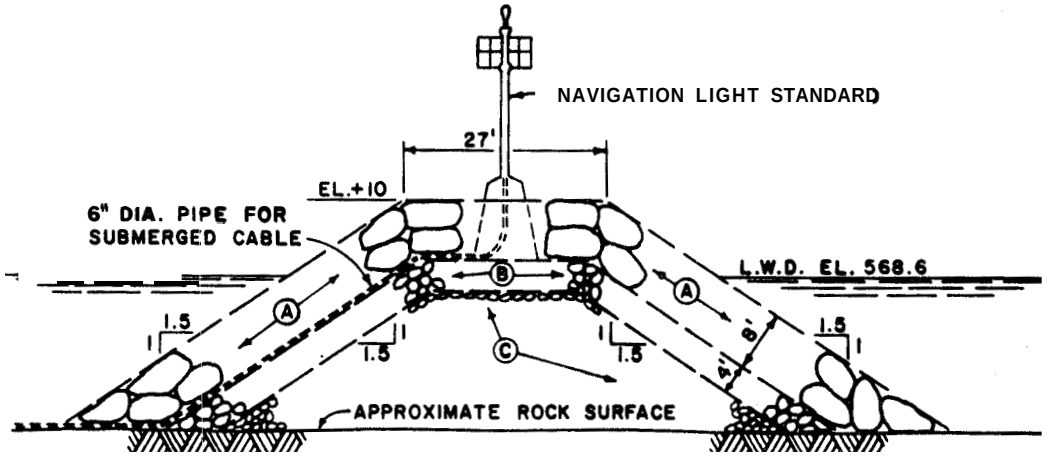
TOE STONE: MINIMUM WEIGHT 7 TONS. MINIMUM THICKNESS 42 INCHES.

Figure 240. Typical east and west breakwater cross sections, Ashtabula Harbor, Ohio



ORIGINAL SECTION OF INNER BREAKWATER-S
(BUILT 1901-1909)

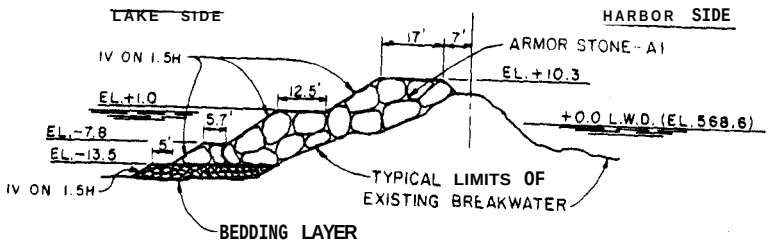
@PLACED COVER STONE S FT. THICK
Ⓑ LARGE RIPRAP.
Ⓒ SMALL RIPRAP.
Ⓓ LAKE SAND,



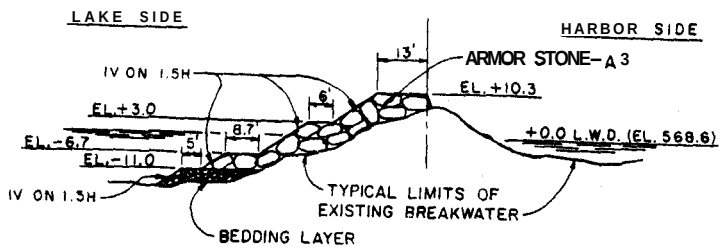
SECTION OF INNER BREAKWATER-S
(WEST END 100'± -BUILT 1977)

Ⓐ COVER STONE: MINIMUM 3.25 TONS- MAXIMUM 7.25 TONS.
Ⓑ UNDERLAYER STONE: 325 LBS. TO 1500 LBS., AVERAGE 500 LBS. TO 1200 LBS.
Ⓒ CORE STONE: I LB. TO 75 LBS., AVERAGE 15 LBS. TO 50 LBS.

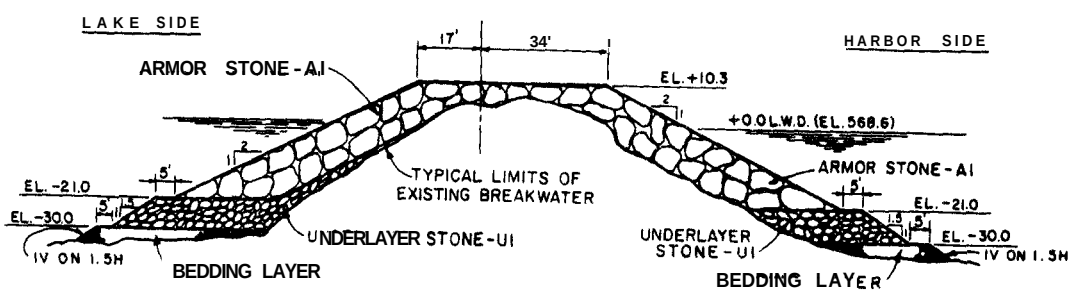
Figure *241.* Typical inner breakwater cross sections, Ashtabula Harbor, Ohio



SECTION OF WEST BREAKWATER
REHABILITATION IN 1981



SECTION OF EAST BREAKWATER
REHABILITATION IN 1981



HEAD SECTION OF EAST BREAKWATER
REHABILITATION IN 1981

BREAKWATER	STATIONS REHABILITATED	ARMOR TYPE	ARMOR SIZE (TONS)	UNDERLAYER SIZE(U1) / (TONS)	BEDDING SIZE (LBS.)	SECTION
WEST	20+50 TO 39+00	A1	8.5-19.0	0.5-2.0	CHIPS TO 200	O
BREAKWATER	7+00 TO 20+50	A2	7.0-15.0	0.5-2.0	CHIPS TO 200	N
EAST	6+50 TO 24+00	A2	7.0-15.0	0.5-2.0	CHIPS TO 200	P
BREAKWATER	24+00 TO 43+50	A3	3.7-8.3	-	CHIPS TO 200	P

Figure *242.* **Typical breakwater cross sections, Ashtabula Harbor, Ohio**

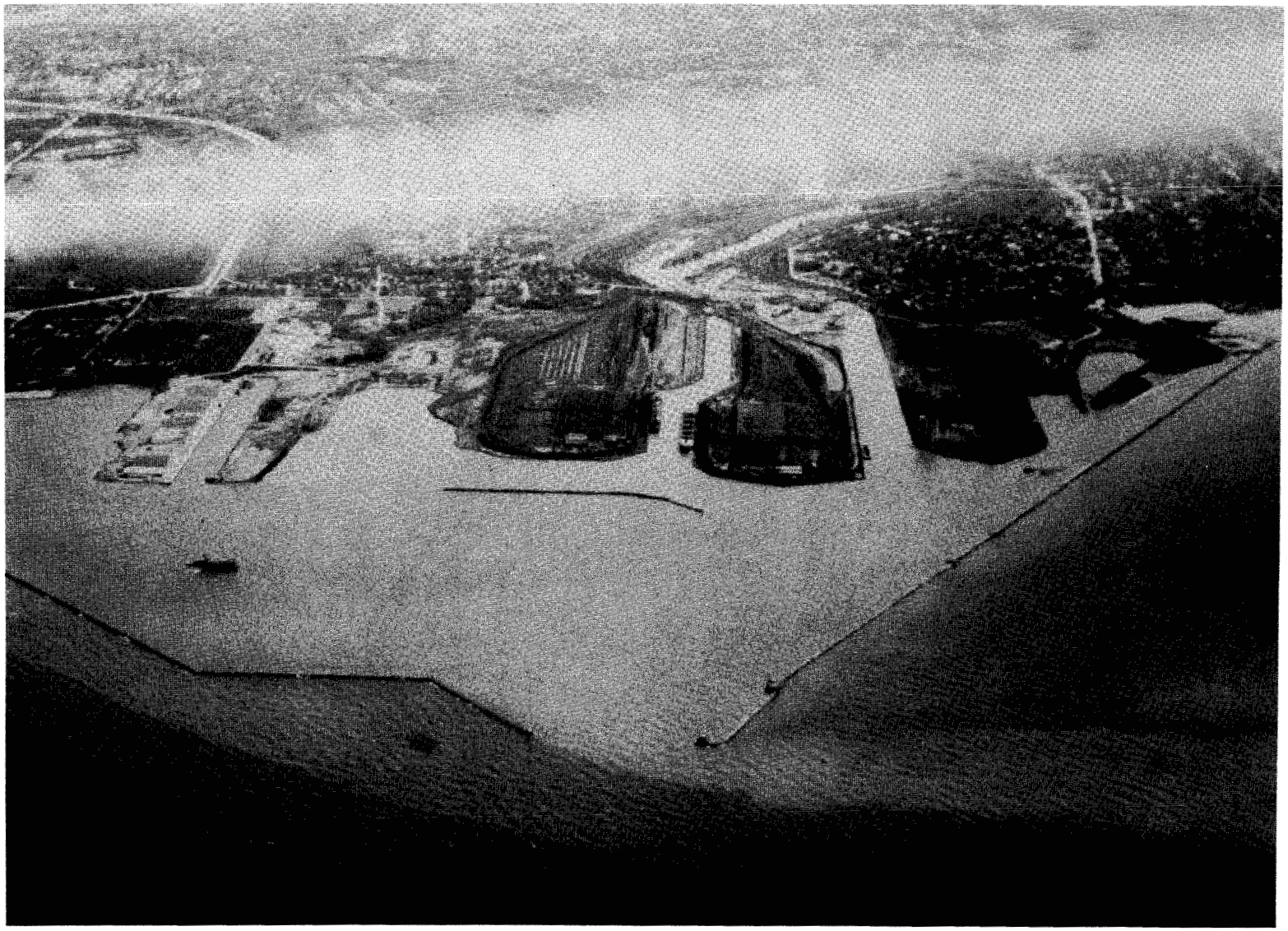


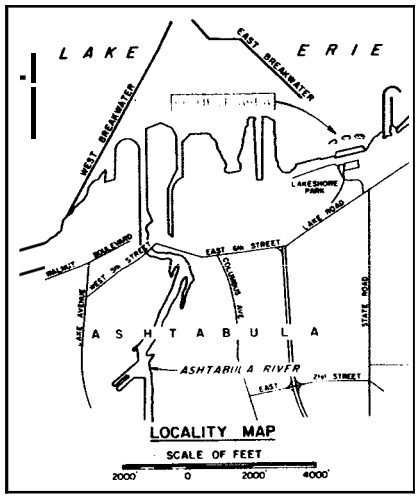
Figure 243. Aerial view of Ashtabula Harbor, Ohio

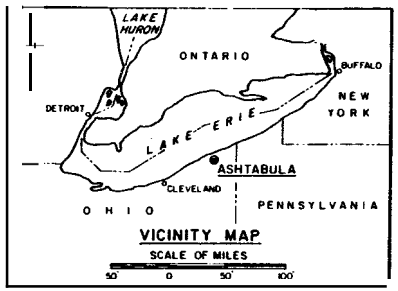
Table 89

Lakeshore Park Breakwaters

Lakeshore Park, Ohio

Date(s)	Construction and Rehabilitation History
1983	Construction of three offshore detached breakwaters, 125 ft long each, was completed (Figure 244) for shoreline protection. The breakwaters were rubble-mound structures with 9.5-ft-wide crests and els ranging from +7.5 to +8.5 ft lwd (Figure *244).* Side slopes were 1V:2H on the lakesides and 1V:1.5H on the harbor sides. Armor stone ranged from **1.5** to 3 tons.
1986	The breakwaters presently are considered to be in good condition, and there are no records of maintenance repair. An aerial photo of the Lakeshore Park breakwaters is shown in Figure 245.





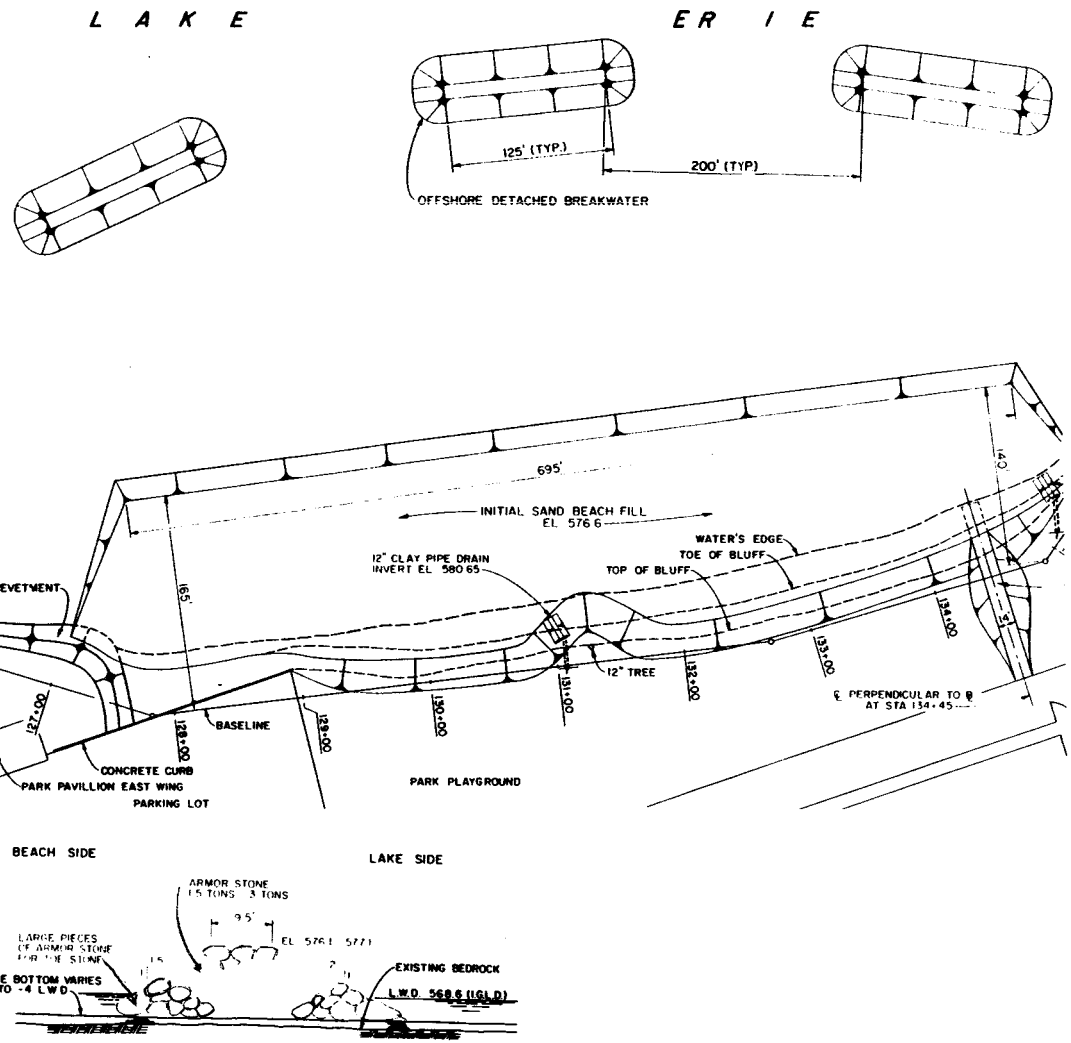


Figure 244. Lakeshore Park, Ohio

Figure 245. Aerial view of Lakeshore Park, Ohio

Table 90

Conneaut Harbor Structures

Conneaut, Ohio

Date(s)	Construction and Rehabilitation History
1894	Construction of the east and west piers (Figure 246) was completed. The piers were constructed of stone-filled timber cribs. (Figures 246, 247, 248, and 249 illustrate structures at Conneaut Harbor.) The east pier was 18 ft wide (Figure 247), and the west pier was 24 ft wide (Figure 249).
1905-1907	The east and west piers were capped with concrete superstructures during this period. The east pier had a crest el of +8.3 ft lwd (Figure 247), and the west pier superstructure was installed at an el of about +6.1 ft lwd (Figure 249). The Corps of Engineers presently maintains only the lakeward 300-ft-long section of the west pier. A 1,054-ft-long portion of the east breakwater (Figure 246, Section C) also was constructed during this time. The breakwater was a 23-ft wide stone-filled timber crib. A concrete superstructure with a crest el of +10.3 ft lwd was included along with a rubble slope on the lakeside (Figure 247, Section C).
1911-1912	An 810-ft-long rubble-mound shoreward extension of the east breakwater (Figure 246, Section A) was completed. The extension had a crest el of +10 ft lwd and a crest width of 10 ft (Figure 247, Section A). Side slopes on the lakeside were 1V:1.5H, and 1V:1.3H on the harbor side. Armor stones greater than 3 tons each were used in construction.
1912-1917	A 3,403-ft-long rubble-mound west breakwater (Figure 246, Sections A and I) was constructed during this time. Breakwater cross sections were similar to those used for the east breakwater extension built during 1911-1912 (Figure 247, Section A, and Figure 248, Section I).
1916-1923	Construction of an 886-ft-long rubble-mound lakeward extension of the east breakwater (Figure 246, Section B) was completed during this time. The structure cross section was similar to the shoreward extension of the east breakwater completed during 1911-1912 (Figure 247, Section B).
1934-1936	Construction of a 935-ft-long rubble-mound lakeward extension of the east breakwater (Figure 246, Section G); an 865-ft-long rubble-mound lakeward extension of the west breakwater (Figure 246, Section F); and a 1,670-ft-long rubble-mound shore arm of the west breakwater (Figure 246, Section H) was completed. The lakeward extensions had 10-ft crest widths and crest els of +10 ft lwd (Figure 248, Sections F and G). Side slopes were 1V:1.3H, and armor stone had a minimum weight of 3 tons with not less than 50 percent of 5 tons or more.

(Continued)

Table 90 (Concluded)

Rate(s)	Construction and Rehabilitation History
	The west breakwater shore arm had a crest el of +8 ft lwd and a width of 10 ft and 1-V:1.3-H side slopes (Figure 248, Section H). Armor stone sizes were the same as those on the lakeward breakwater extensions.
1941-1954	Rehabilitation of a 1,251-ft-long portion of the west breakwater (Figure 246, Section I) was performed. The structure was built up with additional stone to a crest el of 4-10 ft lwd and a crest width of 8 ft (Figure 248, Section I). Side slopes of 1V:1.3H were used, and armor stone with a minimum weight of 3 tons and not less than 50 percent of 5 tons or more was placed.
1954-1960	A 1,552-ft-long portion of the west breakwater trunk was rehabilitated by the installation of additional stone to its original design (Figures 24.6 and 247, Section A).
1963-1964	Rehabilitation of a 600-ft-long portion of the west breakwater (Figures 246 and 247, Section A) and an 800-ft-long portion of the east breakwater (Figures 246 and 247, Sections B and C) was completed. The rubble-mound portions of the breakwaters were repaired by the installation of additional stone to original design specifications.
1965	A 1,187-ft-long cellular steel sheet-pile shoreward east breakwater extension (Figure 246, Sections J and K) was constructed. The cells were granular filled (Figure 249, Sections J and K) and had diameters of about 30.2 (Section J) and 20.7 ft (Section K). They were capped with concrete at an el of +10 ft lwd. Model testing was conducted prior to the construction of this extension (Hudson and Wilson 1963).
1983	Maintenance repair to the west breakwater was performed for a cost of about $310,000.
1986	The structures are presently considered to be in fair condition. The concrete cap in the midsection of the east breakwater (Figures 246 and 247, Section C), particularly, is in need of repair. An aerial view of the Conneaut Harbor structures is shown in Figure 250.

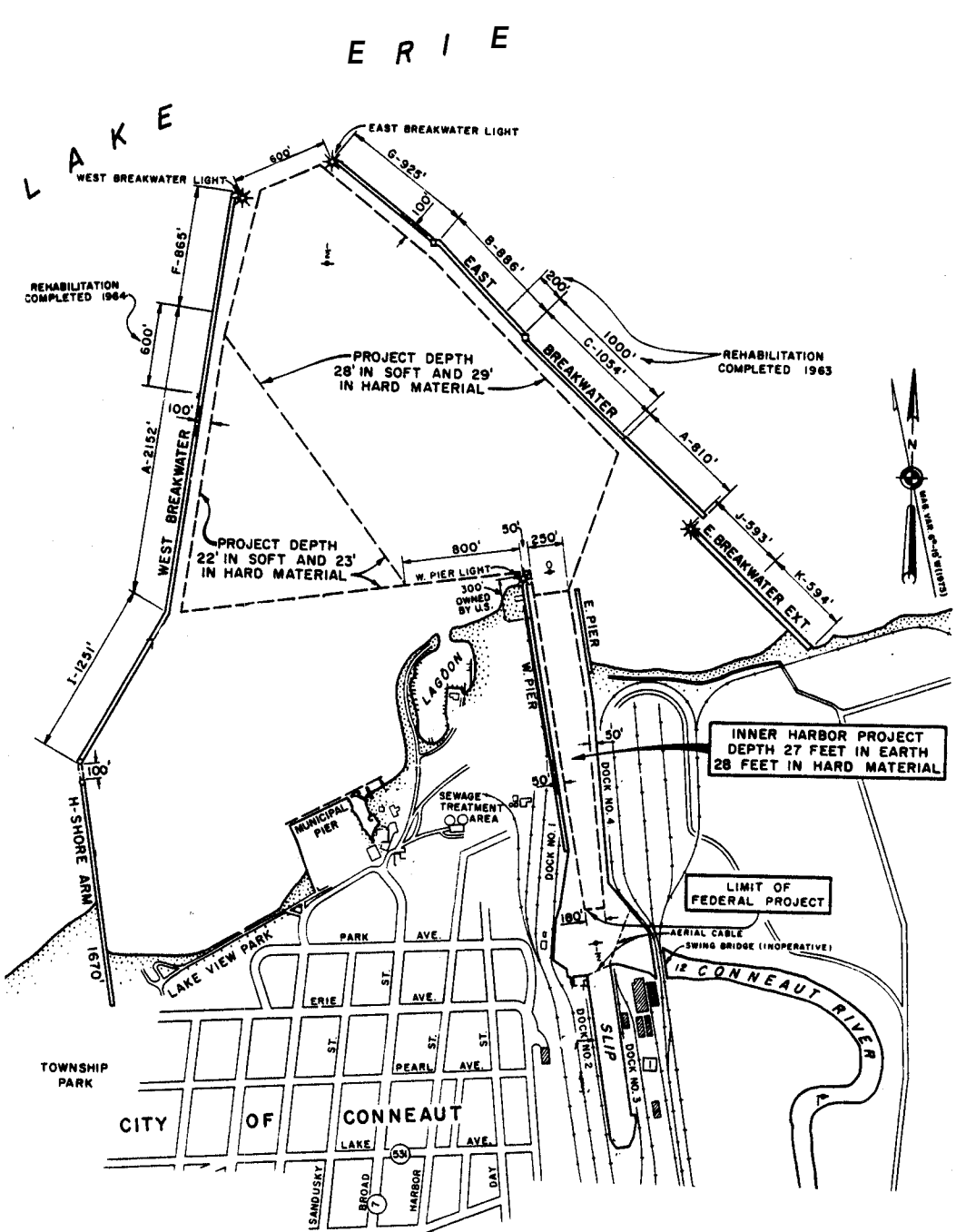
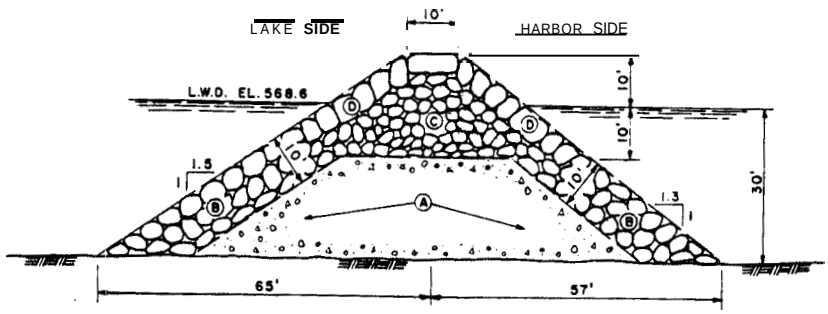


Figure *246*. Conneaut Harbor Ohio

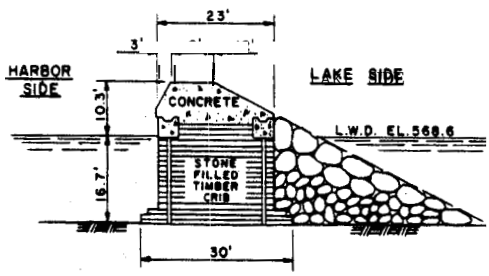


SECTION OF EAST AND WEST BREAKWATERS-A-B

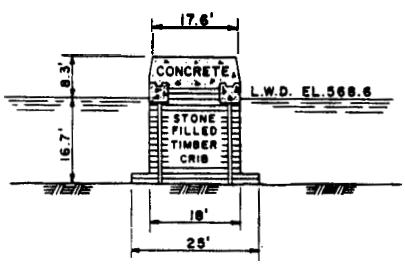
EAST BREAKWATER
("A" SECTION BUILT 1911-1912
"B" SECTION BUILT 1916-1923)
REHABILITION OF 200' OF "B" SECTION INITIATED IN MAY 1963 AND COMPLETED IN JUNE 1964.

WEST BREAKWATER
("A" SECTION BUILT 1912-1917
1,552' REBUILT 1954-1960)
REHABILITION OF 600' INITIATED IN MAY 1963 AND COMPLETED IN JUNE 1904.

(A) QUARRY CHIPS.
(B) QUARRY RUN NOT LESS THAN 3 TONS,
(C) QUARRY RUN BETWEEN 500 LBS, AND 3 TONS.
(D) CAPPING STONE GREATER THAN 3 TONS.

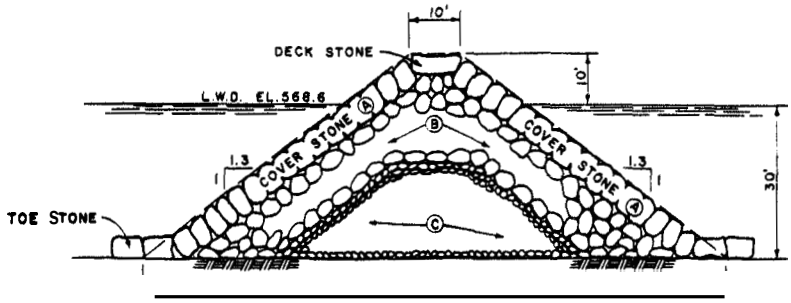


SECTION OF EAST BREAKWATER-C
(BUILT-1005-1907)
REHABILITION OF 1000 FEET INITIATED IN APRIL 1963 AND COMPLETED IN OCTOBER 1963.



SECTION OF EAST PIER
(BUILT 1894, 1907)

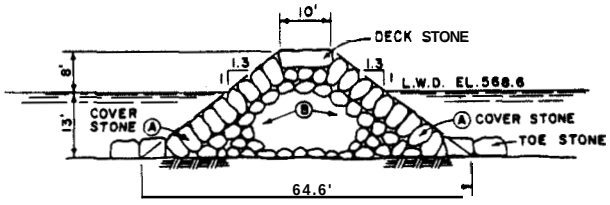
Figure *247.* **Typical structure cross sections, Conneaut Harbor, Ohio**



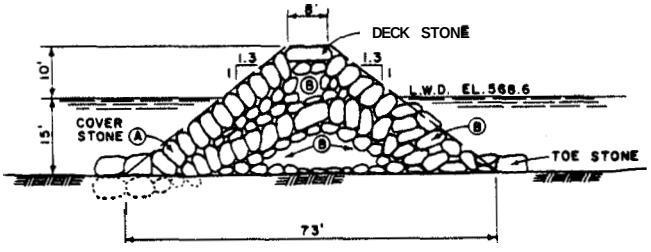
SECTION Of EAST AND WEST BREAKWATERS-F-G

WEST BREAKWATER
("F" SECTION BUILT 1934-1936)

EAST BREAKWATER
("G" SECTION BUILT 1934-1936)



SECTION OF SHORE ARM BREAKWATER-H
(BUILT 1934-1935)



SECTION OF WEST BREAKWATER-I
(BUILT 1912-1917
REBUILT 1941-1954)

SECTIONS-F-G-H-I

OECK STONE: MINIMUM WEIGHT 5 TONS. MINIMUM THICKNESS 30 INCHES.

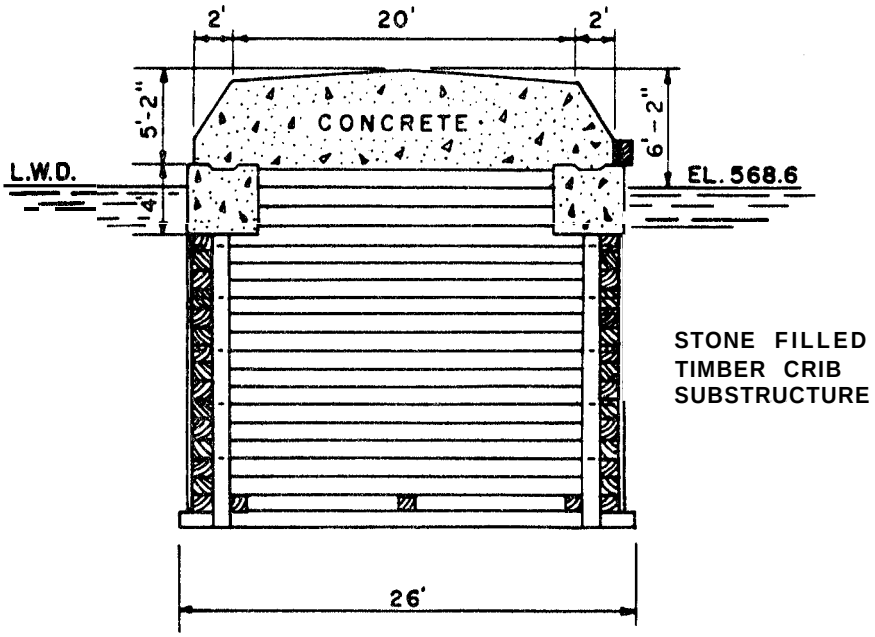
Ⓐ STONE: MINIMUM WEIGHT 3 TONS. NOT LESS THAN SOX 5 TONS OR MORE. MINIMUM THICKNESS 24 INCHES.

@STONE: MINIMUM WEIGHT 150 LIS.

Ⓒ CORE STONE: NOT LESS THAN 35% 75 LBS. NOT MORE THAN 3% WEIGHING LESS THAN I LB. EACH.

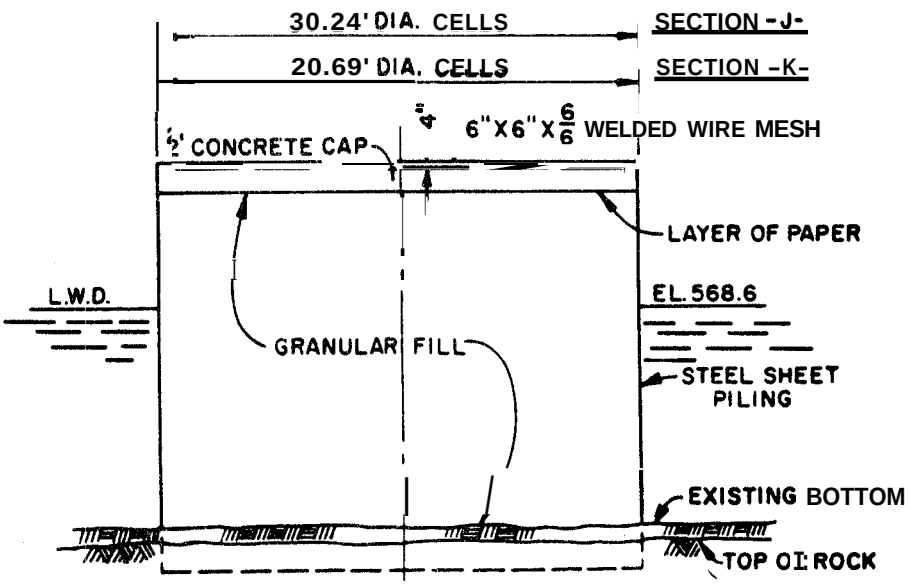
TOE STONE: MINIMUM WEIGHT 7 TONS. MINIMUM THICKNESS 42 INCHES.

Figure *248*. Typical breakwater cross sections, Conneaut Harbor, Ohio



SECTION OF OUTER 300 FEET OF WEST PIER

(OWNED BY U.S. GOVERNMENT)
(BUILT 1894 RECONSTRUCTED 1906)



SECTIONS OF EAST BREAKWATER EKTENSION

(BUILT 1965)

Figure 249. Typical pier and breakwater cross sections, Conneaut Harbor, Ohio

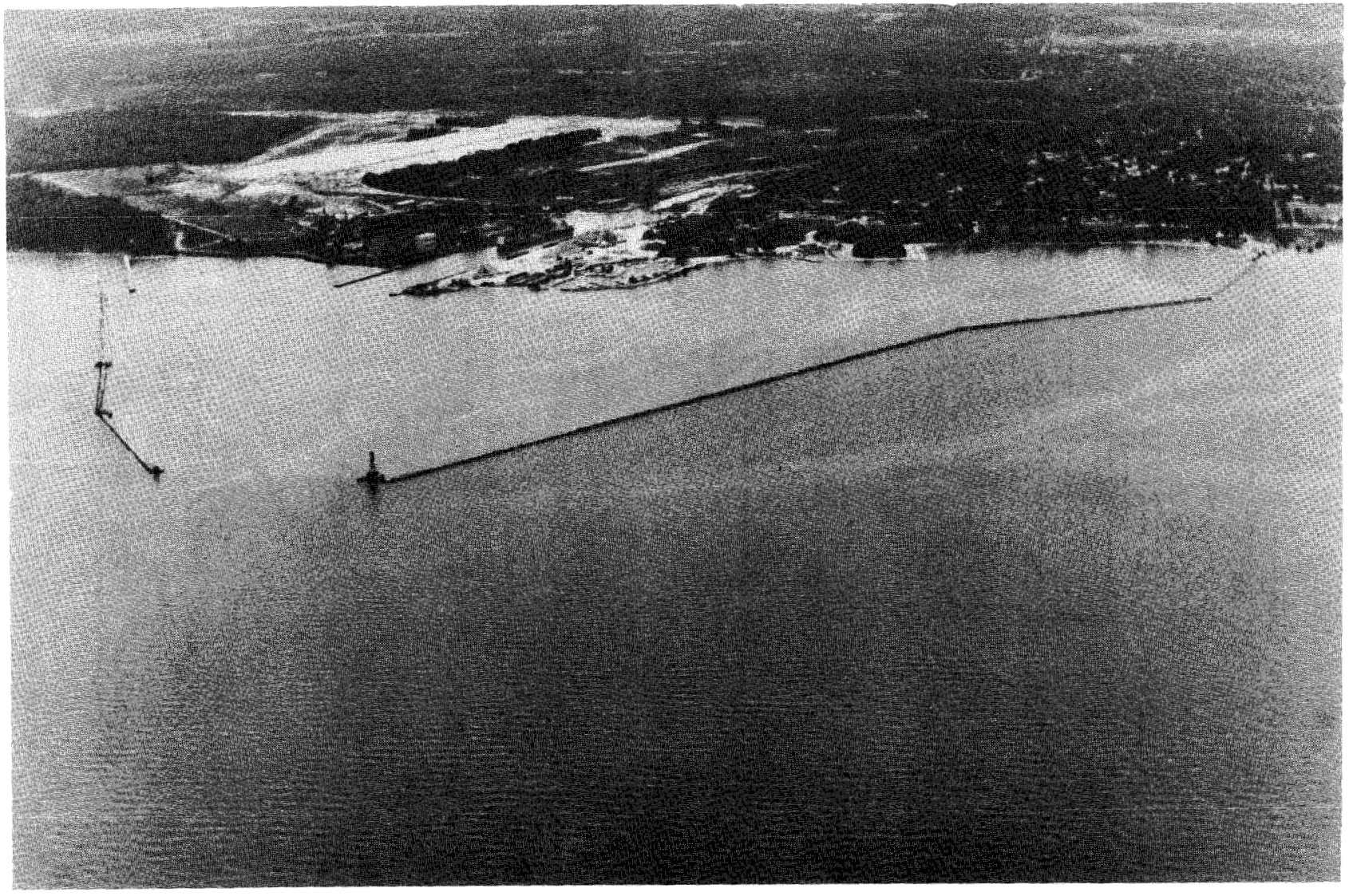


Figure 250. Aerial view of Conneaut Harbor, Ohio

Table 91

Presque Isle Breakwaters

Presque Island Peninsula, Pennsylvania

Date(s)	Construction and Rehabilitation History
1978	Construction of three detached, offshore, rubble-mound, experimental, breakwaters (Figure 251) was completed for beach erosion control. The breakwaters were each 125 ft long and had crest els of +6.0 ft lwd and widths of 6 ft. Side slopes were 1V:2H, and armor stone ranged from 1.5 to 3.5 tons (Figure 251).
1986	There are no records of maintenance repairs to the breakwaters since construction, and they are considered to be in good condition. An aerial view of the Presque Isle experimental breakwaters is shown in Figure 252. A proposal for construction of a series of 58 offshore breakwaters along the Presque Isle Peninsula is being considered. Model tests of a representative portion of the peninsula and some of the breakwaters were conducted (Seabergh 1983).

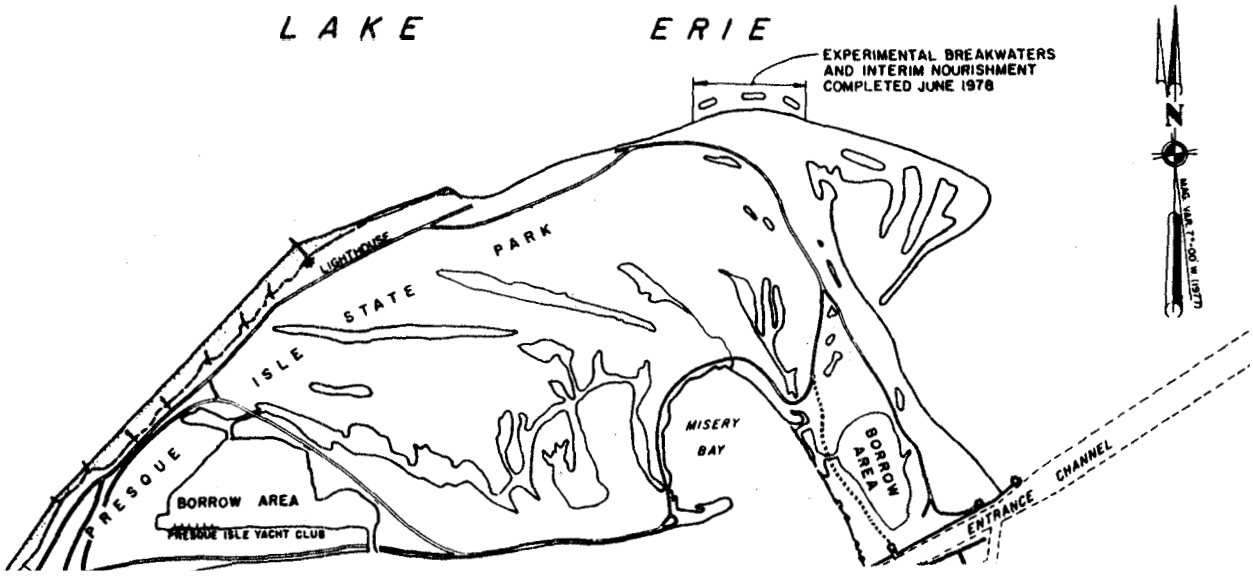


Figure 251. Presque Isle, Pennsylvania

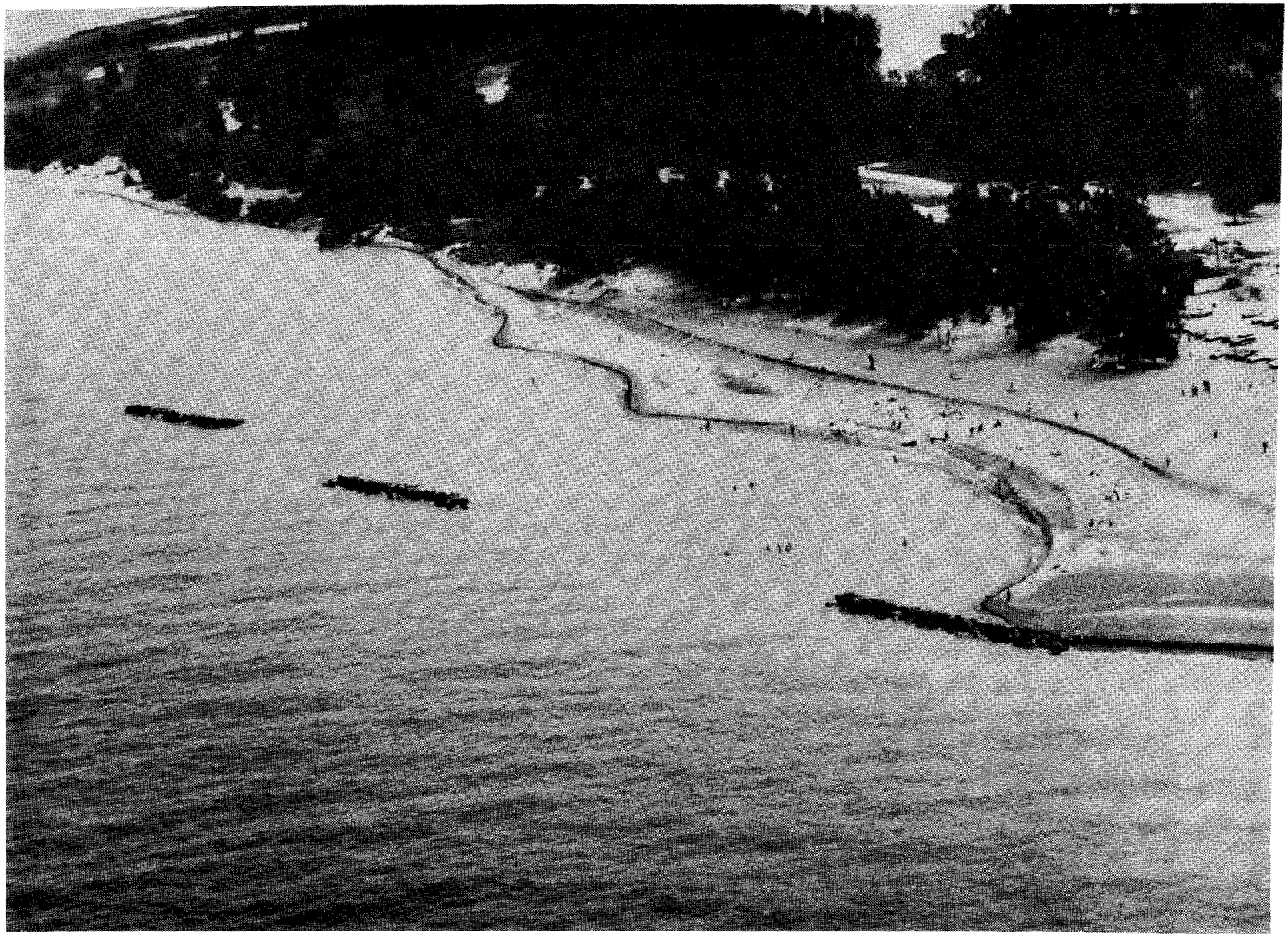


Figure 252. Aerial view of Presque Isle, Pennsylvania

Table 92

Erie Harbor Piers

Erie, Pennsylvania

Date(s)	Construction and Rehabilitation History
1825-1900	Constructfon of a 3,248-ft-long north pier (Figure 253) was completed during this time. The pier was a stone-filled timber crib structure that ranged in width from 16.5 to 30 ft (Figure 254).
1827-1903	Construction of a 2,215-ft-long south pier (Figure 253) was completed during this period. This pier was also a stone-filled timber crib structure that was 18 ft wide (Figure 254).
1903-1909	Concrete and stone superstructures were installed on the north and south piers (Figure 254). The crest el of the south pier was +6.3 ft lwd, and the el of the north pier varied from section to section.
1953-1956	Rehabilitation and repair of portions of the north pier were performed. Portions of the pier were repaired by the installation of steel sheetpiling, granular fill, and a new concrete cap (Figure 254, Sections A and D). A total of 1,141 ft of the north pier superstructure was rebuilt.
1979	A disposal. dike was constructed adjacent to the south pier (Figure 253).
1984	Portions of the north pier were repaired (Figure 253, Sections A, F, and G). These piers were encased in steel sheetpiling. The voids between the sheetpiling and the existing timber cribs were granular filled, and the structure was recapped with concrete (Figure 255). The shoreward end of the north pier (Section A) was approximately 21 ft in width with a crest el of +7.3 ft lwd. The lakeward portions of the pier (Section F and G) were about 28 ft wide with an el of +9.8 ft lwd.
1986	The piers are presently considered to be in good condition. An aerial photo of the Erie Harbor piers prior to the construction of the disposal dike is shown in Figure 256.

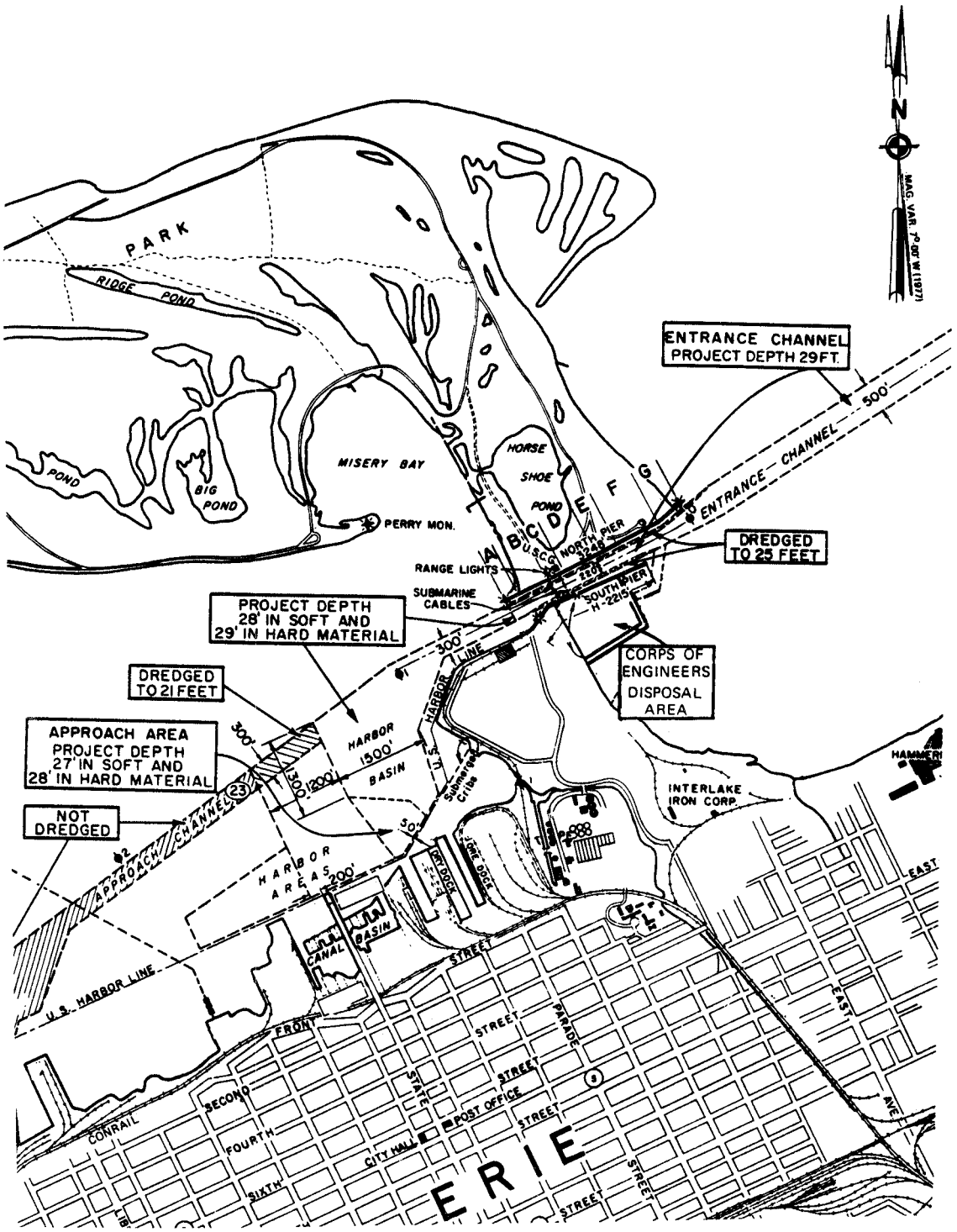
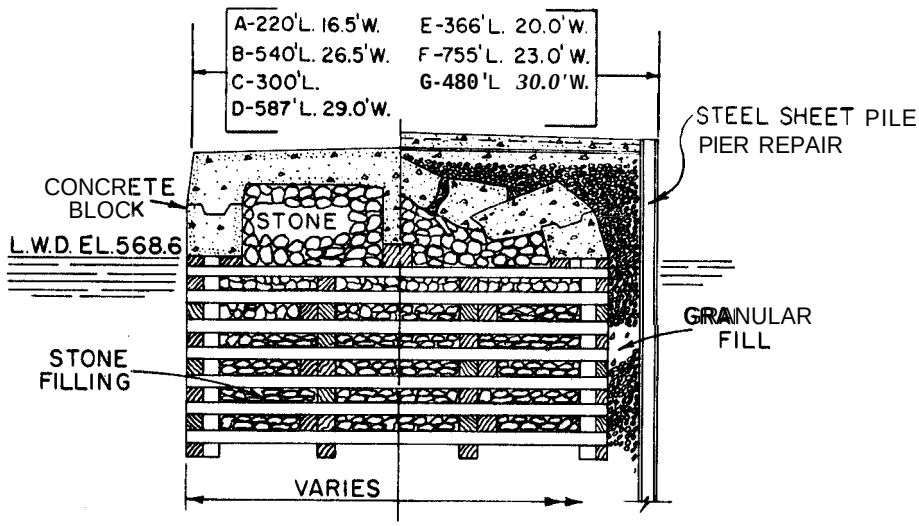


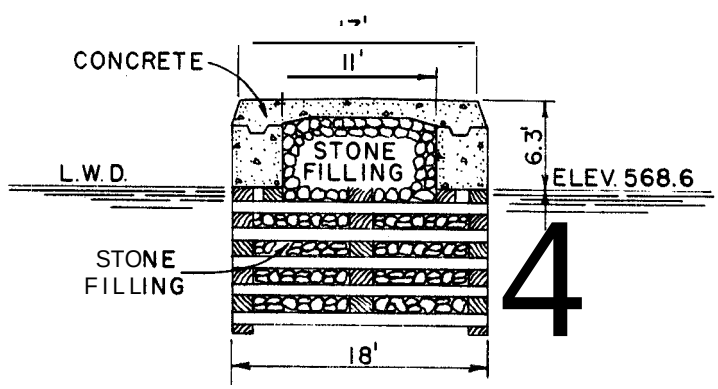
Figure 253. Erie Harbor, Pennsylvania



SECTION OF NORTH PIER

(BUILT 1825-1900 SUPERSTRUCTURE 1903-1909)
(REBUILT 1141 FEET OF SUPERSTRUCTURE 1953-1956)

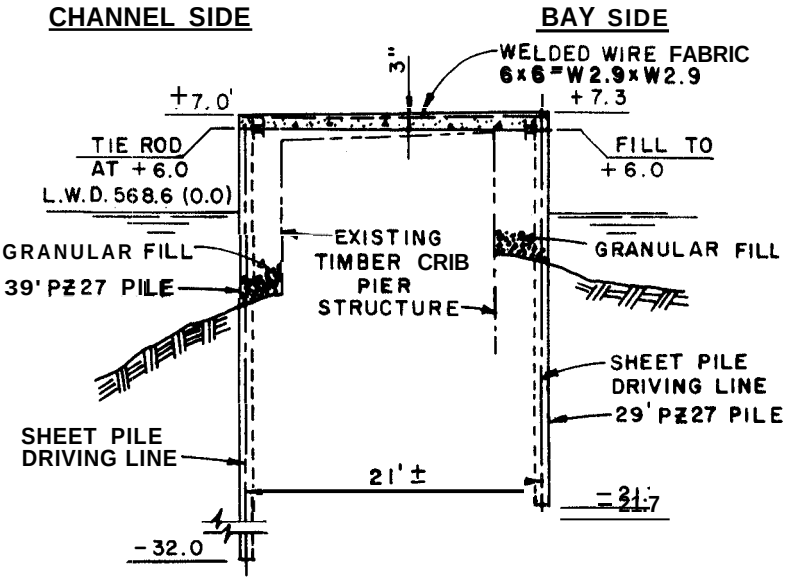
A-REPAIRED IN 1953-1954
D-REPAIRED IN 1954-1955



SECTION OF SOUTH PIER-H

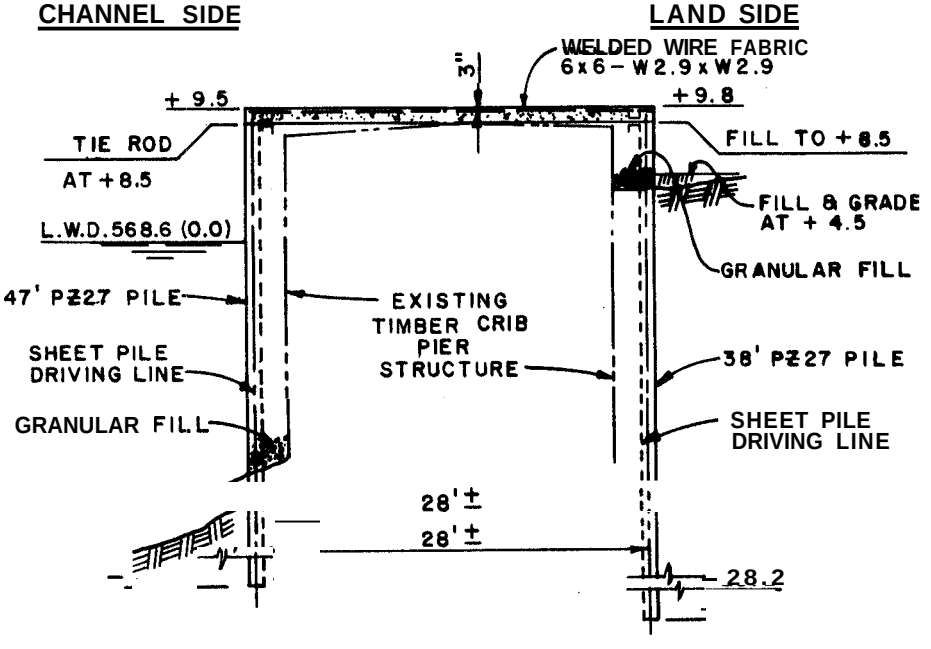
(BUILT 1827-1903 SUPERSTRUCTURE 1903-1909)

Figure *254.* **Typical pier cross sections, Erie Harbor, Pennsylvania**



SECTION OF NORTH PIER-A

REPAIRED 1984



SECTION OF NORTH PIER-F-G

REPAIRED 1984

Figure 255. Typical north pier cross sections, Erie Harbor, Pennsylvania

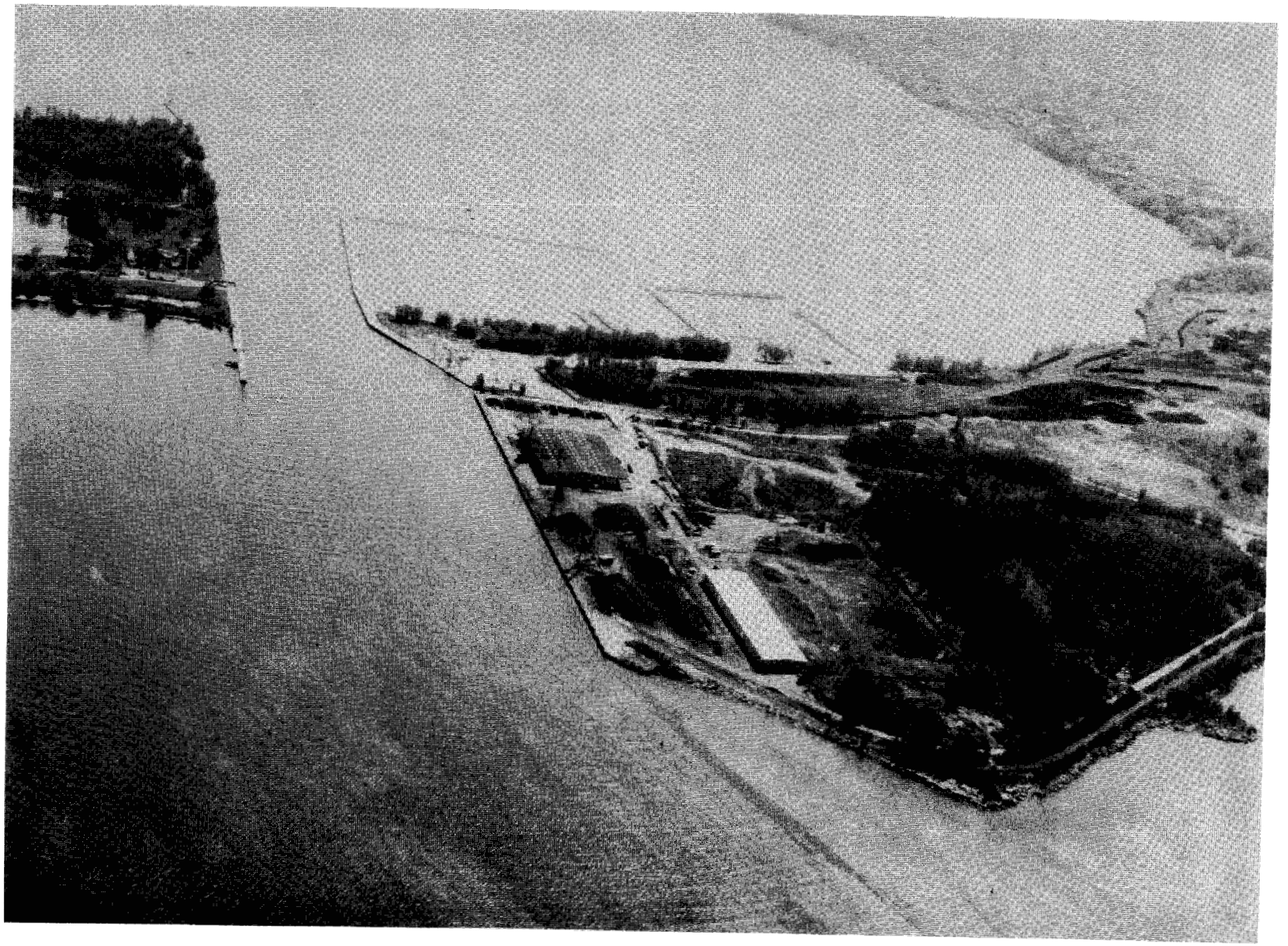


Figure 256. Aerial view of Erie Harbor, Pennsylvania

Table 93

Barcelona Harbor Breakwaters

Barcelona, New York

Date(s)	Construction and Rehabilitation History
1960	Construction of a 693-ft-long east and a 790-ft-long west breakwater (Figure 257) was completed, The breakwaters were constructed with cellular steel sheetpiling filled with granular fill and capped with concrete. The cell diameters were about 38 ft, and the els were +9 and +11 ft lwd for the east and west structures, respectively (Figure 257). A 174-ft-long steel sheet-pile shore arm connected the west breakwater to shore. Its el was +9 ft lwd.
1984	Construction of a 250-ft-long lakeward west breakwater extension, a 150-ft-long shoreward east breakwater extension, and segmented wave absorbers adjacent the harbor side of the west breakwater was completed (Figure 257). The modifications were constructed of rubble-mound materials. The west breakwater extension consisted of a structure with a crest el of +11 ft lwd, a crest width of 12 ft, side slopes of 1V:1.5H, and armor stones ranging from 7.5 to 16 tons. The east Shoreward extension had an el of +8 ft lwd, a crest width of 8 ft, side slopes of 1V:1.5H, and armor stones ranging from 1.2 to 2.5 tons. The modifications were model tested prior to construction (Bottin 1984).
1986	The structures are presently in good condition. An aerial photo of the Barcelona Harbor breakwaters is shown in Figure 258.

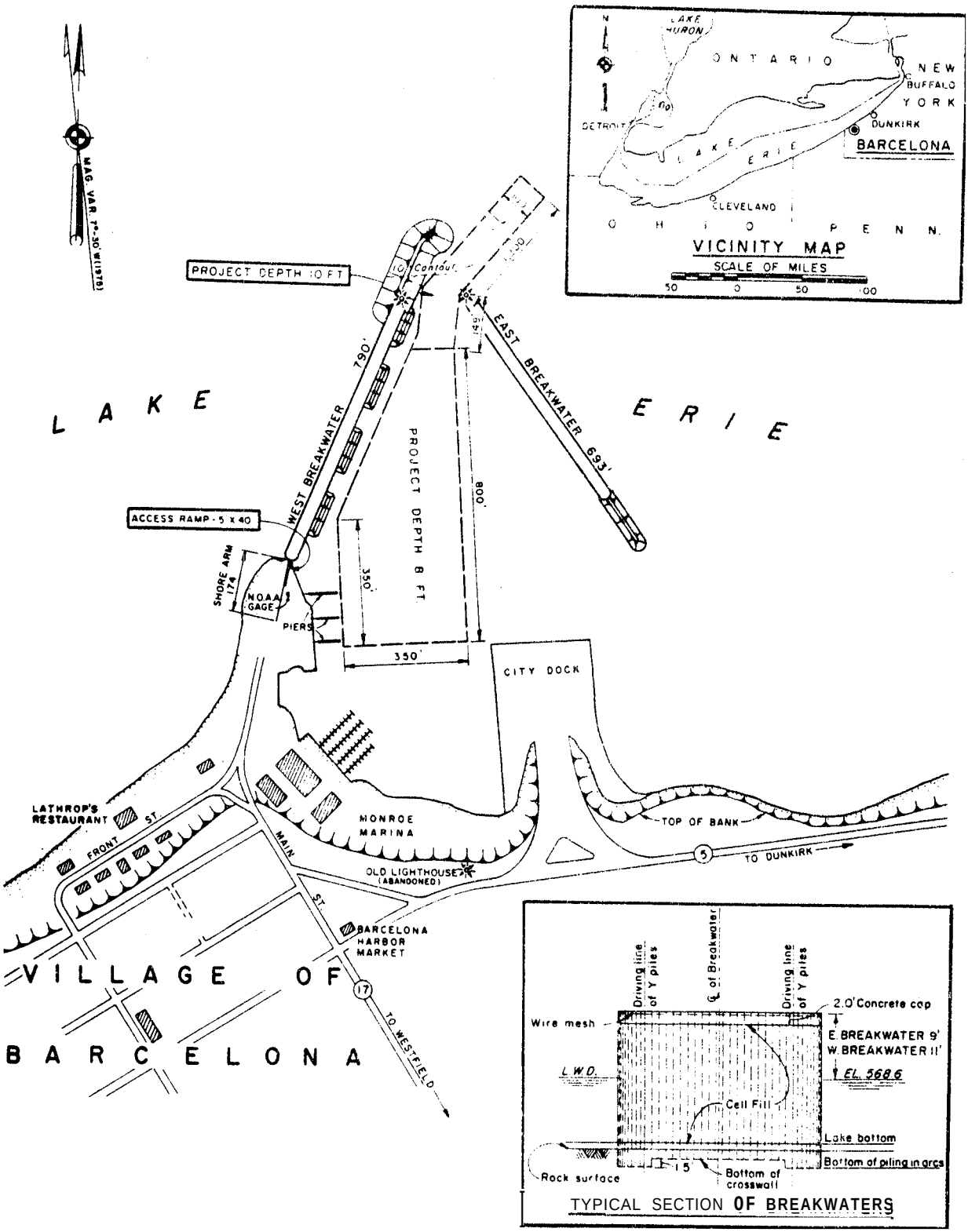


Figure *257.* **Barcelona** Harbor, **New York**

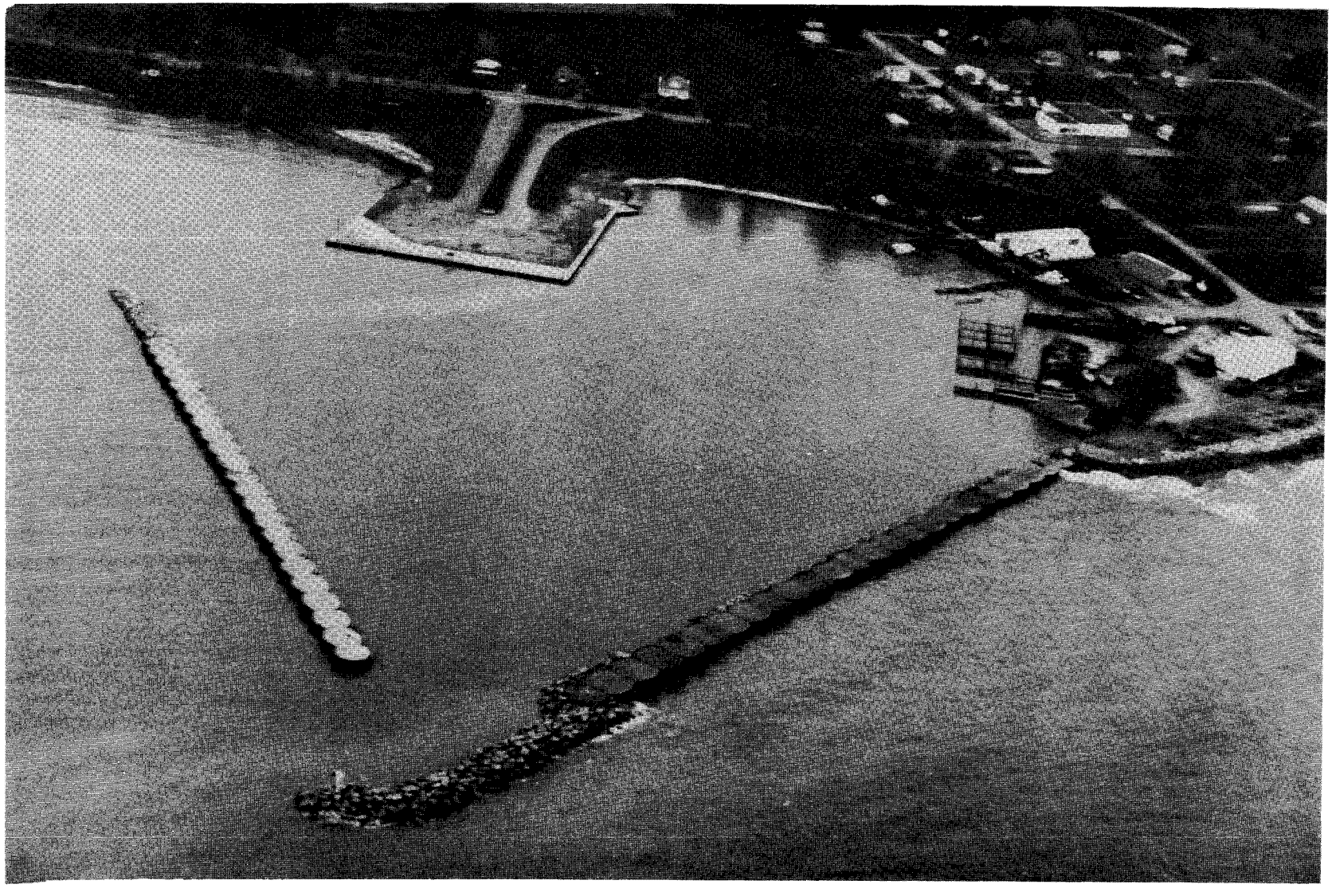


Figure 258. Aerial view of Barcelona Harbor, New York

Table 94

Dunkirk Harbor Structures

Dunkirk, New York

Date(s)	Construction and Rehabilitation History
1868-1870	Construction of a 1,410-ft-long west pier (Figure 259, Section I) was completed during this time. The pier was constructed of concrete and stone (Figure 260, Section I) and was 30 ft in width.
1897-1921	A concrete superstructure was installed on most of the west pier. The maximum el of the superstructure was +11.3 ft lwd (Figure 260, Section I). A small portion of the superstructure next to the shoreline was constructed with large stone.
1898	Construction of a 577-ft-long portion of the outer breakwater (Figure 259, Section J) was completed. The breakwater was a stone-filled timber crib structure that was 30 ft in width (Figure 260, Section J).
1899	Construction of a 2,237-ft-long portion of the outer breakwater (Figure 259, Sections G and H) was completed. The structure was 30 ft wide and consisted of stone-filled timber cribs (Figure 260, Sections G and H). A concrete superstructure was installed on a 310-ft-long portion of the breakwater (Section G). It had an el of +10.3 ft lwd (Figure 260).
1930	A concrete superstructure was installed on a 577-ft-long portion of the outer breakwater (Figure 259, Section J). The maximum el of the superstructure was +8 ft lwd (Figure 260, Section J). Stone riprap was placed along the lakeside at the west pier also during this year.
1931	A stone superstructure was installed on a 1,827-ft-long portion of the outer breakwater (Figure 259, Section H). The el of the superstructure was +8.3 ft, and it had a 10-ft crest width (Figure 260, Section H). The stone extended along the lakeside of the breakwater on a 1-V:1.5-H slope. A 110-ft-long portion of Section H (Figure 259) included a precast concrete superstructure.
1979-1980	Construction of a 1,200-ft-long west and 1,464-ft-long east breakwater (Figure 259) was completed during this period. The structures were rubble mound with els of +11 ft lwd, crest widths of 10 ft, side slopes of 1V:1.5H, and armor stones ranging from 1,400 to 3,800 lbs.
1986	The inner rubble-mound breakwaters presently are in good condition, and the west pier and outer breakwater are considered to be in fair condition. The concrete portions of the superstructure of the outer breakwater and pier show signs of spalling and slight separation at the joints; however, no immediate action is required. The stone superstructure portions of the outer breakwater seem to have settled lakeward in areas, and additional stone has been recommended to increase the height of the structure to its original design. An aerial view of the Dunkirk Harbor structures is shown in Figure 261.

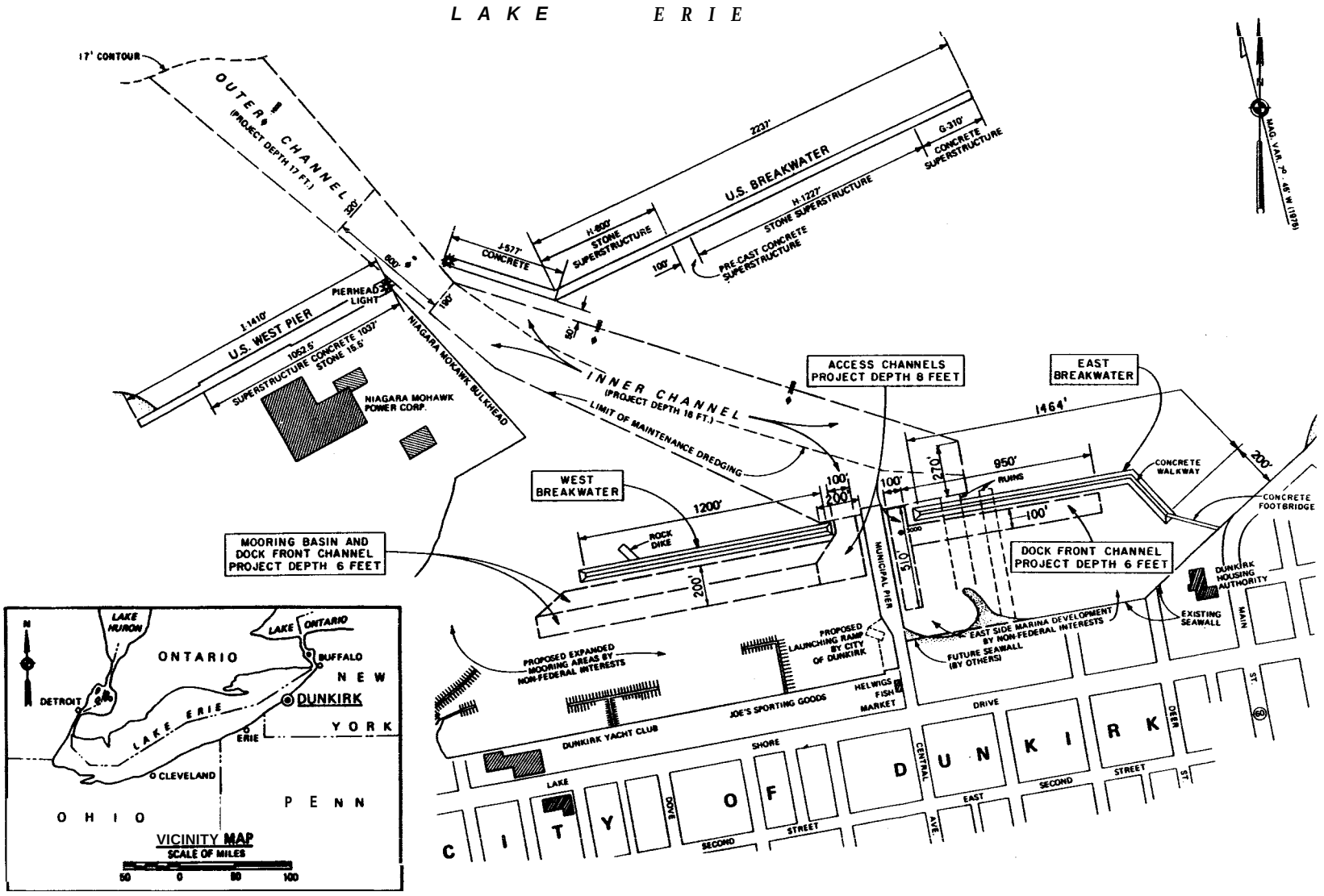
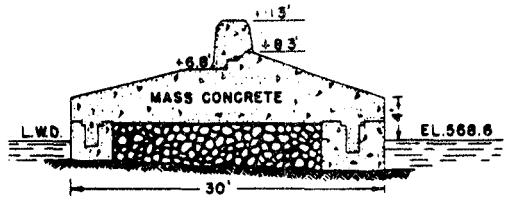
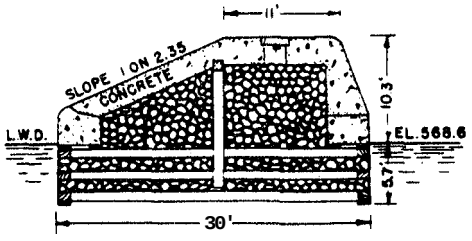


Figure 259. Dunkirk Harbor, New York



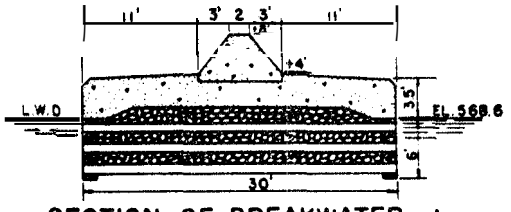
SECTION OF WEST PIER -I-

(BUILT 1868-1870)
CONC. SUPER-STRUCTURE 1897-1921
STONE RIPRAP 1930



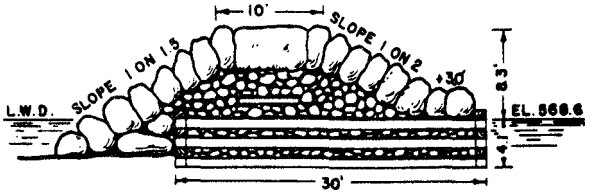
SECTION OF BREAKWATER -G-

(BUILT IN 1899)



SECTION OF BREAKWATER -J-

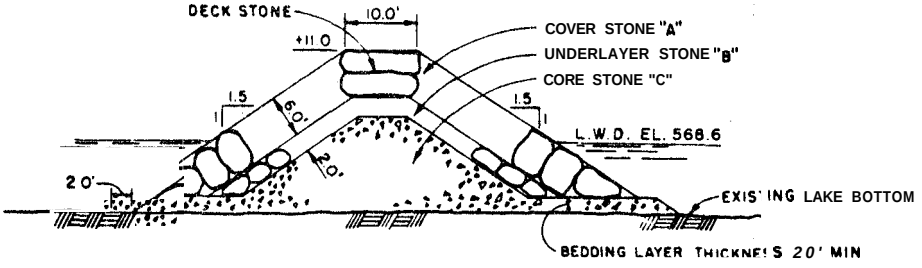
(BUILT IN 1898)
CONC. SUPER-STRUCTURE IN 1930



SECTION OF BREAKWATER -H-

(BUILT IN 1899 STONE SUPER-STRUCTURE IN 1931)

LAKESIDE LANOSIOE



EAST AND WEST INNER BREAKWATER

(BUILT 1979-1980)

STONE GRADATION

"A" Stone 1400lbs. - 3800lbs.
"B" Stone 90 lbs. - 380 lbs
"C" Stone Chips - 20lbs.

Figure 260. Typical structure cross sections, Dunkirk Harbor, New York

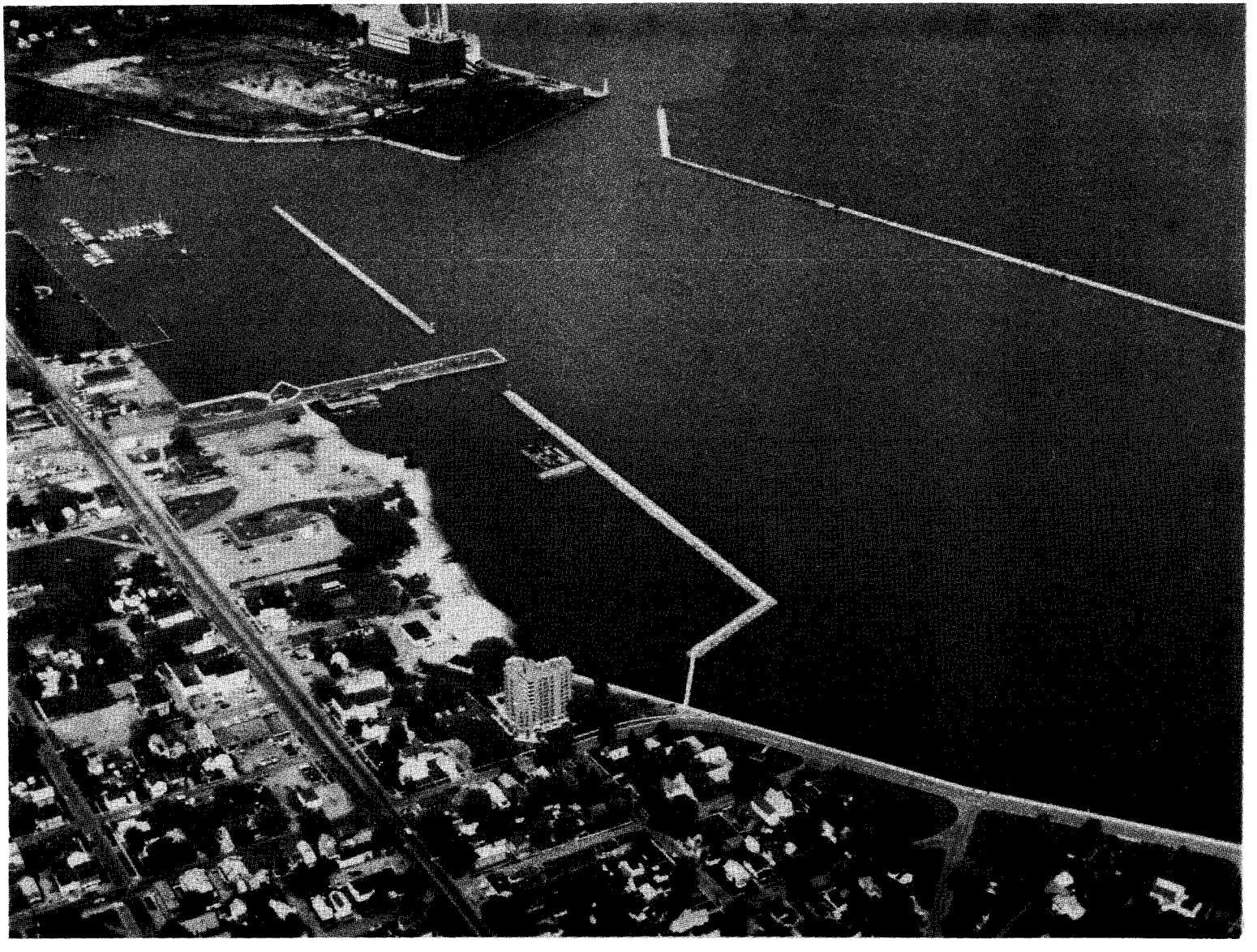


Figure 261. Aerial view of Dunkirk Harbor, New York

Table 95

Cattaraugus Creek Harbor Breakwaters

Hanover. New York

Date(s)	Construction and Rehabilitation History
1983	Construction of two rubble-mound breakwaters was completed (Figure 262). The north breakwater was 600 ft long with a crest el of +12.5 ft lwd and a crest width of 11 ft (Figure 263). Side slopes were 1V:2H, and armor stone ranged from 2 to 5 tons. The south breakwater was 1,850 ft long and included armor stone that ranged from 4 to 9 tons. It included a +12.5 ft lwd crest el, a 13.5-ft crest width, and 1-V:2-H side slopes (Figure 263). The cost of construction was about $6.1 million, which included a 550-ft-long berm attached to the north breakwater (Figure 262). The breakwater configuration was model tested prior to construction (Bottin and Chatham 1975).
1986	No maintenance repairs have been performed, and the structures are in good condition. An aerial photo of the Cattaraugus Creek breakwaters is shown in Figure 264.

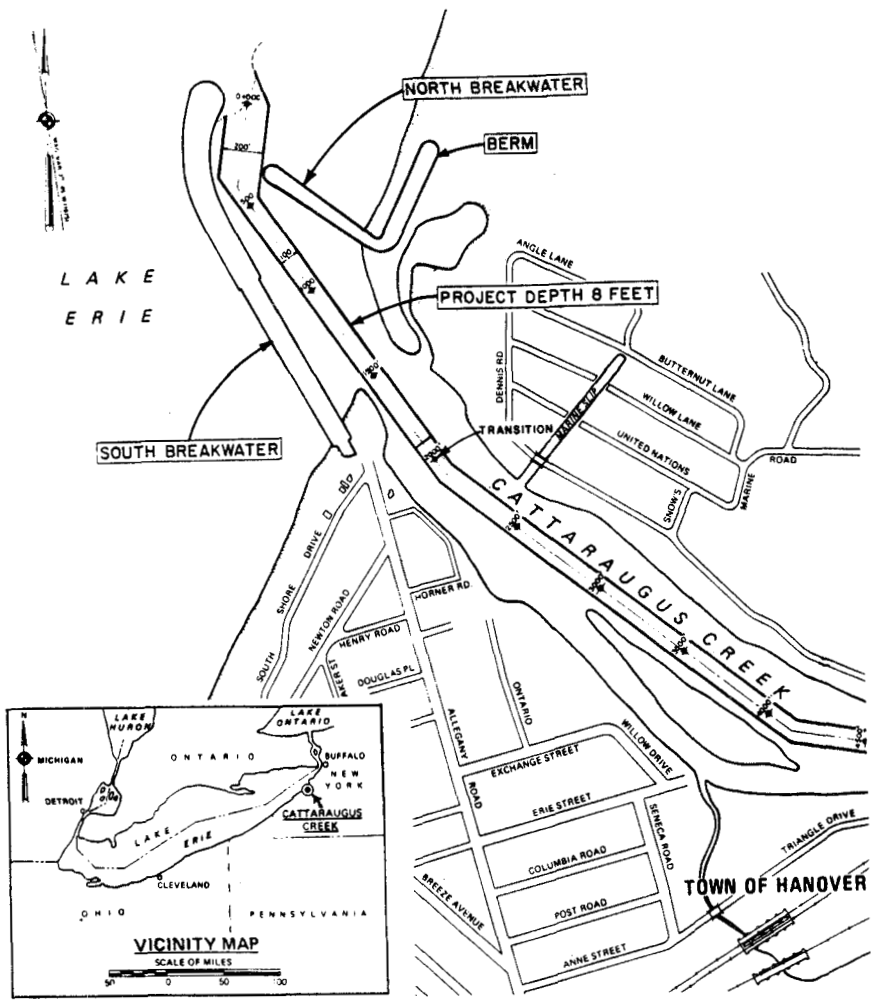
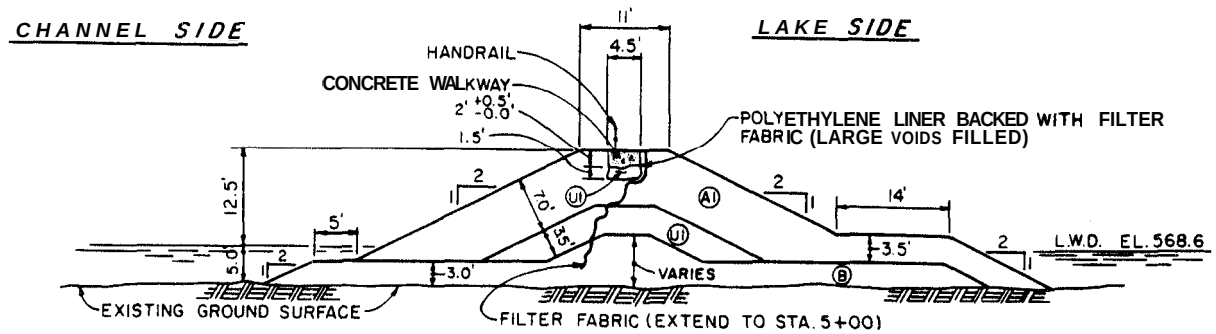
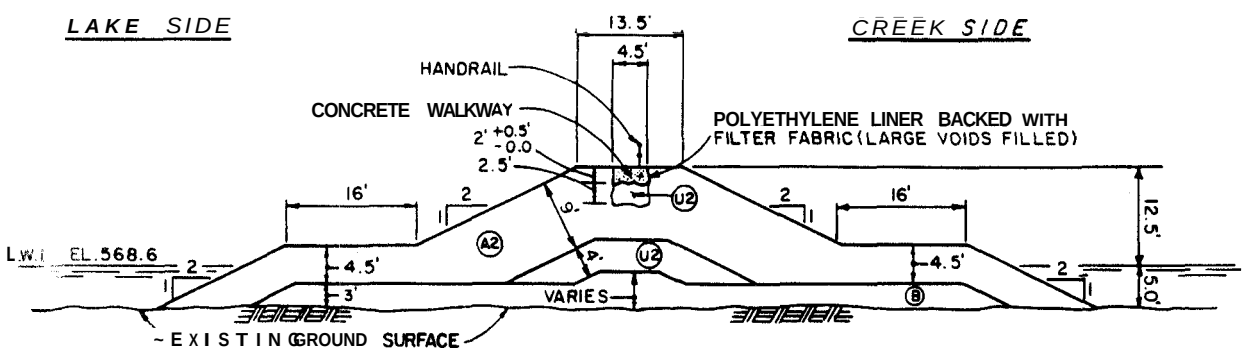


Figure 262. Cattaraugus Creek Harbor, New York



TYPICAL SECTION OF NORTH BREAKWATER



TYPICAL SECTION OF SOUTH BREAKWATER

AI - ARMOR STONE: 2 TO 5 TONS
A2 - 4 TO 9 TONS
A3 - 6 TO 13 TONS

B - BEDDING STONE: 6" TO 10" IN.

U1 - UNDERLAYER STONE: 240 TO 950 LBS.
U2 - 460 TO 1850 LBS.
U3 - 640 TO 2550 LBS.

Figure 263. Typical breakwater cross sections, Cattaraugus Creek Harbor, New York

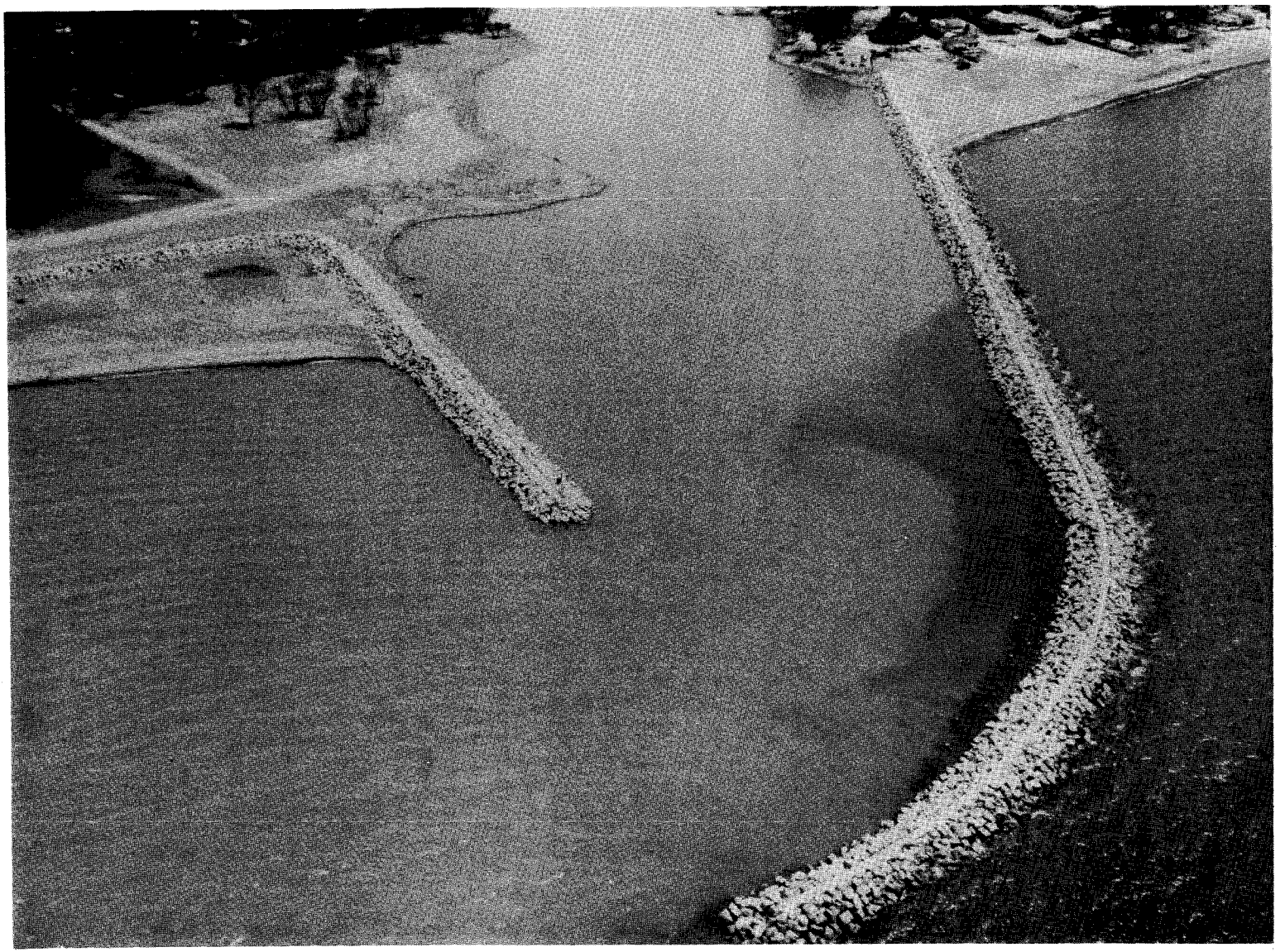


Figure 264. Aerial view of Cattaraugus Creek Harbor, New York

Table 96

Buffalo Harbor Breakwater

Buffalo, New York

Date(s)	Construction and Rehabilitation History
1869-1893	Construction of the Old Breakwater (Figure 265, Sections C and D) was completed during this period. The original length of the structure was 7,609 ft, and it consisted of stone-filled timber cribs (Figure 266, Section C and Figure 267, Section D) that were 36-ft in width.
1889	A concrete superstructure was installed on a portion of the Old Breakwater (Figure 265, Section C). The crest el of the structure was +14.5 ft lwd (Figure 266, Section C).
1897-1898	Construction of the 1,603-ft-long Stony Point breakwater (Figure 265, Section K) was completed. It consisted of 36-ft-wide stone-filled timber cribs (Figure 266, Section K).
1897-1902	Construction of a 2,204-ft-long north breakwater (Figure 265, Sections A and B) and a 10,200-ft-long south breakwater (Figure 265, Sections E, F, G, and H) was completed during this time. The north breakwater was constructed with 24-ft-wide (Figure 268, Section B) and 36-ft-wide (Figure 268, Section A) stone-filled timber cribs. Concrete and stone superstructures were included which had crest els of +13.5 ft lwd (Figure 268, Sections A and B). Portions of the south breakwater were constructed with 36-ft-wide stone-filled timber cribs (Figure 266, Section G and Figure 268, Sections F and H). Section G (Figure 266) included a concrete and stone superstructure with a crest el of +15 ft lwd. Section H (Figure 268) included a concrete superstructure with an el of +14.5 ft lwd, and Section F (Figure 268) had a stone superstructure with an el of +14.5 ft lwd and a 14-ft-wide crest width sloping to the lake on the lakeside. Section E (Figure 266) was a rubble-mound structure with a crest el of +14.5 ft and a width of 14 ft. Slopes on the harbor side ranged from 1V:0.7H to 1V:1.22H to 1V:2.5H. Armor stone on the lakeside was approximately 6.5 tons in weight.
1902-1927	Riprap was placed on the lakeside of a portion of the south breakwater (Figures 265 and 266, Section G). The stone ranged from 0.5 to 4 tons each.
1907-1924	A stone superstructure with a concrete cap was installed on a portion of the Old Breakwater (Figures 265 and 267, Section D). The crest of the breakwater was 12 ft in width with a crest el of +14.5 ft lwd. Slopes on the harbor side were 1V:0.7H, and slopes on the lakeside ranged from 1V:1.25H to 1V:2.5H.
1923-1924	A stone superstructure with a concrete cap was placed on the Stony Point breakwater (Figures 265 and 266, Section K). The structure had

(Continued)

Table 96 (Concluded)

Date(s)	Construction and Rehabilitation History
	a crest el of +12 ft lwd with slopes of 1V:1H on the harbor side and 1V:1.5H on the lakeside.
1930-1934	Major repairs were performed on portions of the Old Breakwater (Figures 265 and 266, Section C). Portions of the concrete superstructure were replaced, and a protective stone slope was installed on the lakeside of the structure.
1936	A 2,000-ft-long south entrance arm breakwater (Figure 265, Section J) was constructed. The structure was built with rubble-mound materials and had a +14.2 ft lwd crest el with a 10-ft width. Slopes on the harbor side were 1V:1.3 and 1V:1.5H, and slopes on the lakeside were 1V:1.5H. Armor stone weight was 3 tons (min), with not less than 50 percent being 5 tons or more.
1959-1962	A portion of the Old Breakwater was removed, resulting in a 982-ft gap for a new entrance channel (Figure 265). A 1,800-ft-long rubble-mound west breakwater (Figure 265) with a concrete cap was constructed to provide wave protection to the new entrance. The breakwater had a crest el of +12.2 ft with a width of 8 ft. Side slopes were 1V:1.3H on the harbor side and 1V:1.5H on the lakeside. Armor stone was 7 tons (min) each. These modifications were model tested prior to construction (Hudson, Housley, and Wilson 1960).
1964-1965	Rehabilitation of portions of the old breakwater (Figure 265) was completed. Repairs consisted of reconstruction of the stone slopes adjacent to the sea sides of the structures. The cost of improvements was about $220,000.
1977	A disposal dike was constructed adjacent to the south entrance arm breakwater (Figure 265).
1982	A major storm occurred in January with wind gusts reaching 75 mph, resulting in extraordinary sized storm waves. An inspection of the harbor breakwaters subsequent to the storm revealed damages to about 300 ft of the north breakwater. Concrete caps were dislodged, and core stone was exposed. Rehabilitation was recommended.
1983-1984	Recommended repairs with stone and concrete to about 300 ft north of the breakwater were completed for a cost of about $900,000. New armor stone ranging from 6 to 13 tons was utilized (Figure 269). The crest of the new stone was +13.5 ft lwd.
1986	The breakwaters are presently considered to be in good to fair condition. There are isolated areas of settlement along the length of the Old Breakwater, the south breakwater, and the west breakwater. No immediate repairs are required, but the structures are being monitored for signs of accelerated deterioration. An aerial view of the Buffalo Harbor breakwaters is shown in Figure 270.

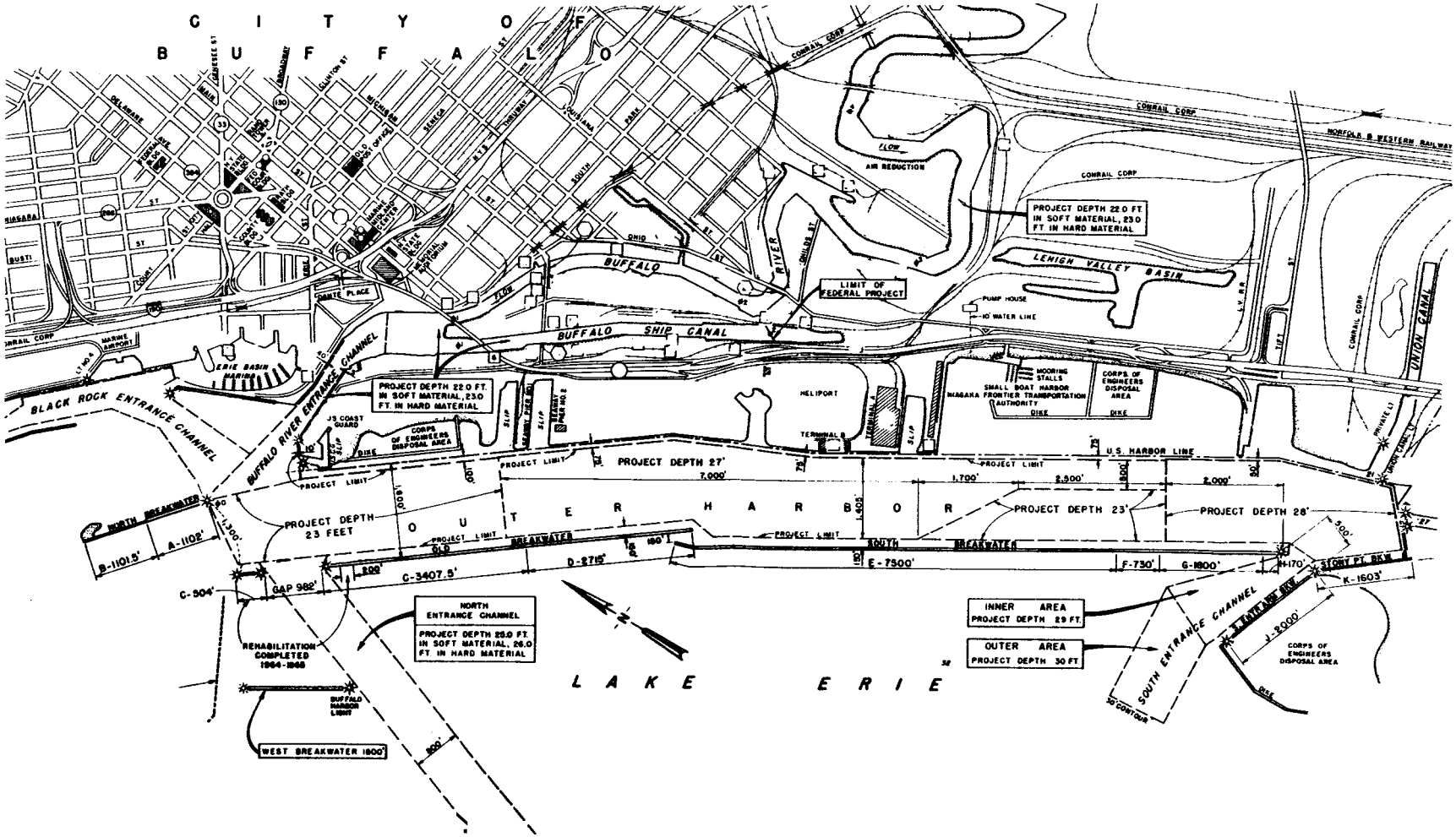
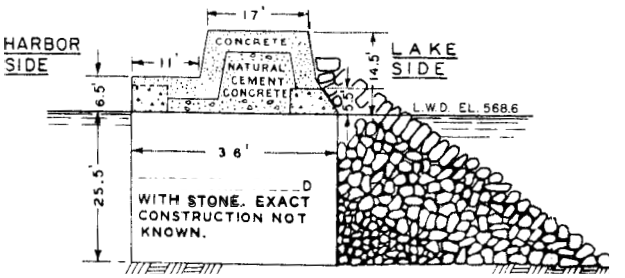
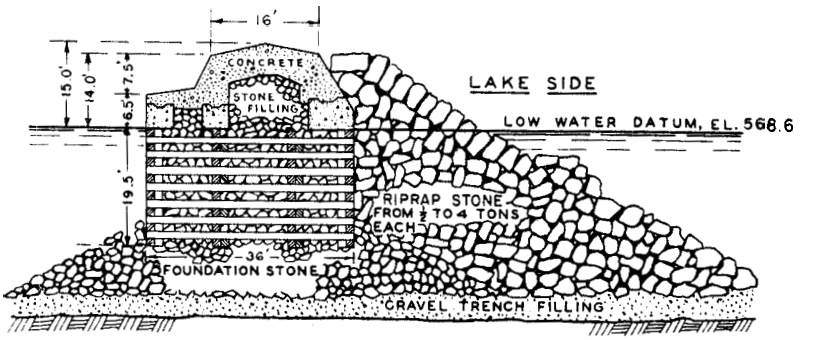


Figure 265. Buffalo Harbor, New York

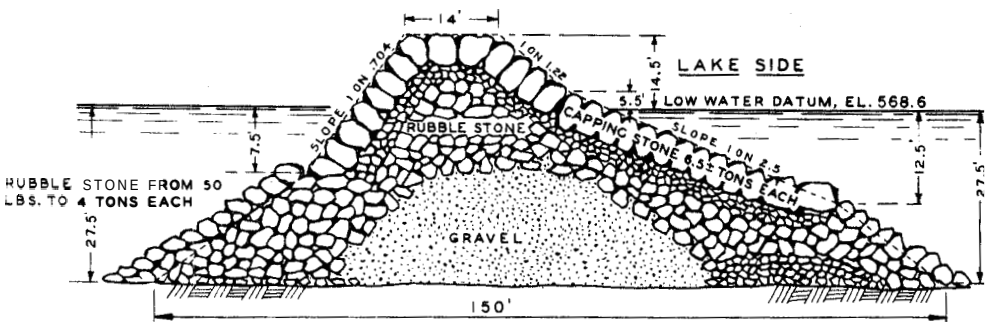
Rehabilitation of portions of Section C commenced on 24 Moy 1964 The northerly 451 feet of the breakwater northerly of the North Entrance Channel, and o 200 foot section about 300 feet southerly of the North Entrance Channel were repaired and additiongl riprap on the harbor stde was placed Rehabilitation was completed on 31 August 1965.



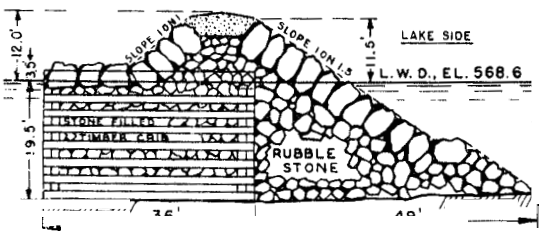
SECTION OF OLD BREAKWATER -C-
(BUILT SUPER-STRUCTURE 1889)



SECTION OF SOUTH BREAKWATER -G-
BUILT 1897-1902)
(SUPER-STRUCTURE 1902-1927)

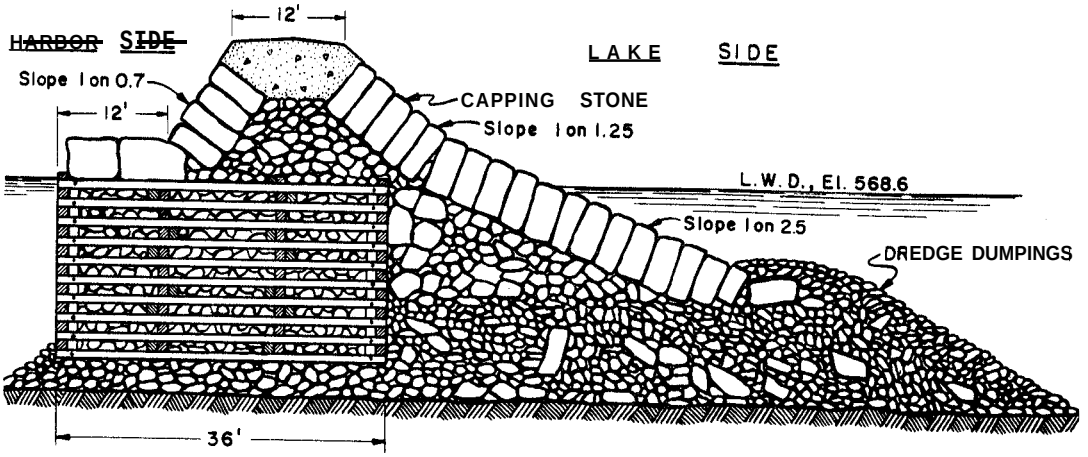


SECTION OF SOUTH BREAKWATER -E-
(BUILT 1897-1902)



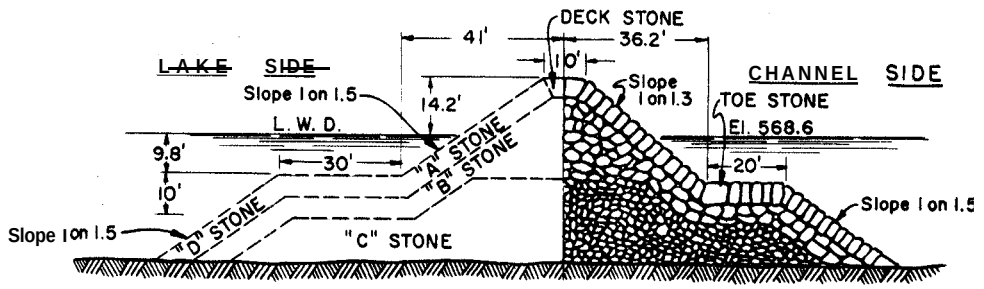
SECTION OF STONY PT. BKW. -K-
(BUILT 1897-1898) (SUPER-STRUCTURE **1923-1924)**

Figure 266. Typical old, south, and Stony Pt. breakwater cross sections, Buffalo Harbor, New York



SECTION OF OLD BREAKWATER -D-

(SUB-STRUCTURE BUILT 1869-1893
SUPER-STRUCTURE BUILT 1907-1924)

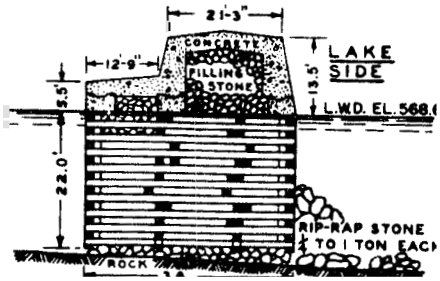


SECTION OF SOUTH ENTRANCE ARM BREAKWATER -J-

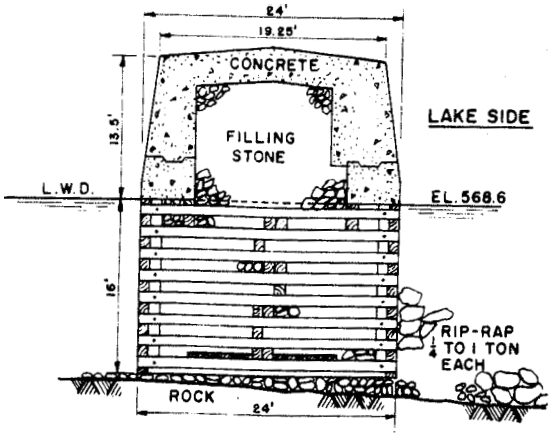
(BUILT IN 1936)

Deck Stone – Minimum weight 5 tons
"A" Stone – Minimum weight 3 tons, not less thon 50% 5 tons or more.
"D" Stone – Minimum weight 3 tons
Toe Stone – Minimum weight 7 tons
"B" Stone – Minimum weight 100 pounds.
"C" Stone – Not less thon 35% 75 pounds or more, not more than 3% less tkon onepound.

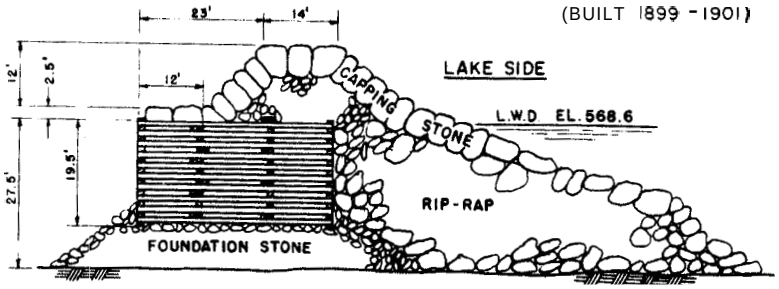
Figure 267. Typical old and south entrance arm breakwater cross sections, Buffalo Harbor, New York



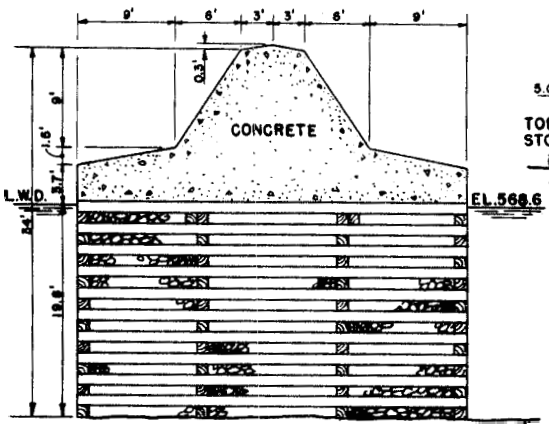
SECTION OF
NORTH BREAKWATER -A-
(BUILT 1899 - 1901)

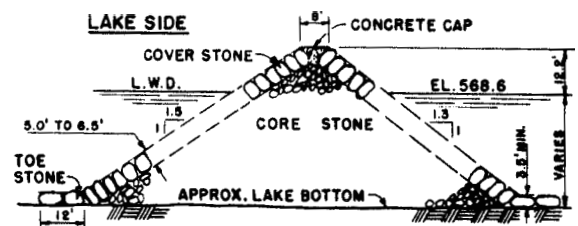


SECTION OF
NORTH BREAKWATER -B-
(BUILT 1899 - 1901)



SECTION OF
SOUTH BREAKWATER -F-

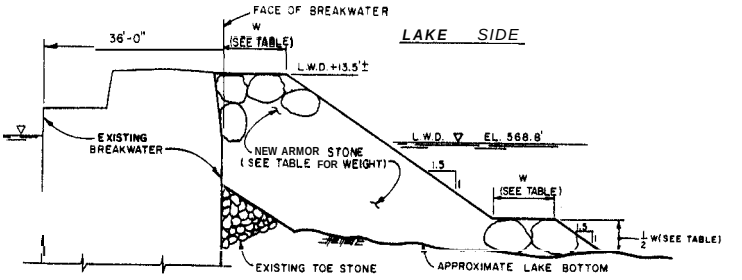




SECTION OF
WEST BREAKWATER

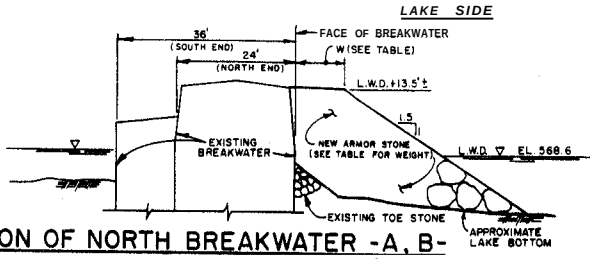
SECTION OF
SOUTH BREAKWATER -H-

Figure 268. Typical structure cross sections, Buffalo Harbor, New York



SECTION OF NORTH BREAKWATER -A-

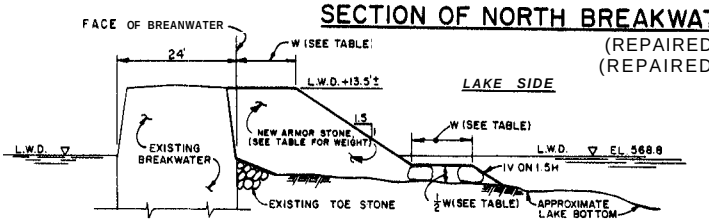
(SOUTH END SECTION REPAIRED 1984)



SECTION OF NORTH BREAKWATER -A, B-

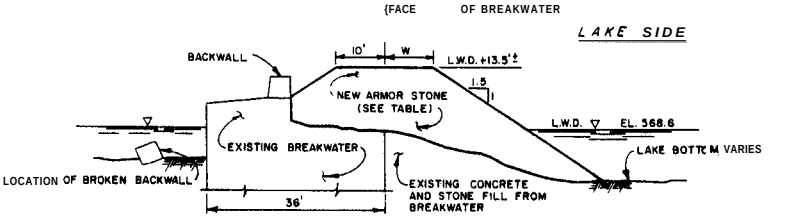
(REPAIRED 1982)

(REPAIRED 1984)



SECTION OF NORTH BREAKWATER -B-

(NORTH END SECTION REPAIRED 1984)



SECTION OF NORTH BREAKWATER -A-

(REPAIRED 1982)

ARMOR STONE

SECTION - A		SECTION - B		SECTION - A and B	
"W" FEET	TONS	"W" FEET	TONS	"W" FEET	TONS
11	9 - 13	9	6 - 10	10	6 - 13
11	9 - 13	9	6 - 10	10	6 - 13
12	10 - 15	9	7 - 11	10.5	7 - 15

Figure 269. Typical north breakwater cross sections, Buffalo Harbor, New York

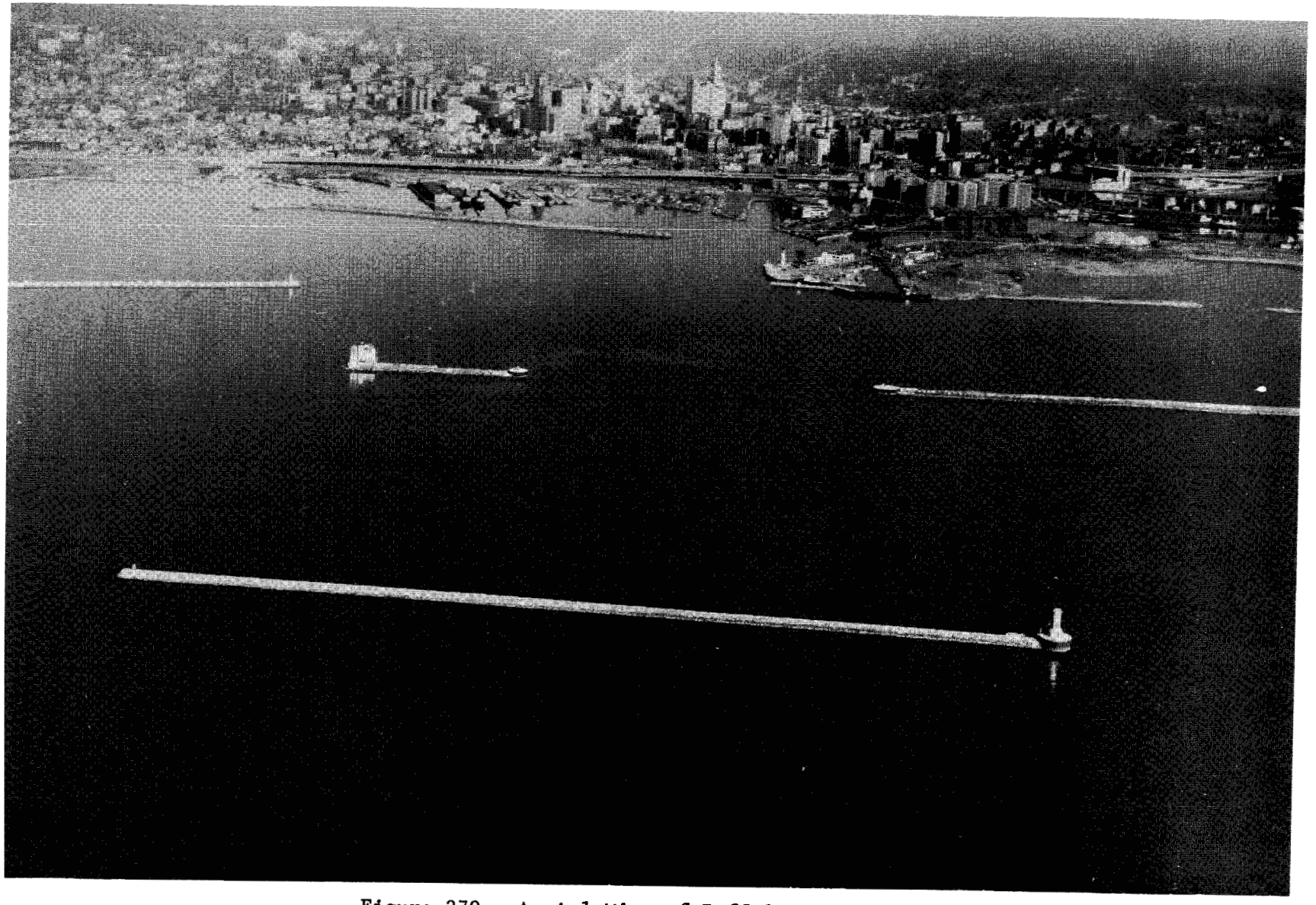


Figure 270. Aerial View of Buffalo Harbor New York

Table 97

Bird Island Pier

Black Rock Channel, Buffalo, New York

Date(s)	Construction and Rehabilitation Historv
1822-1825	Construction of a 6,606.5-ft-long portion of the pier (Figure 271, Section Z) was completed during this time period. The structure consisted of stone-filled timber cribs that were 18 ft in width (Figure 272, Section Z). The pier originally included a timber deck.
1837-1937	The entire 6,605.5-ft-long structure (Figure 271, Section Z) was rebuilt during this period. The pier was capped with stone to an el of about +9 ft lwd, and stone slopes were included on each side of the pier (Figure 271, Section Z).
1869-1892	A 3,100-ft-long extension of the pier (Figure 271, Section Y) was completed during this time. The extension consisted of stone-filled timber cribs that were 20 ft in width (Figure 272, Section Y). A timber deck was installed initially.
1928-1929	The 3,100-ft-Long pier extension (Figure 271, Section Y) was capped with a concrete superstructure. The maximum el of the superstructure was +10 ft lwd (Figure 272, Section Y).
1928-1938	An additional 800-ft-long extension of the pier (Figure 271, Section X) was completed during this period. This extension was a rubble-mound structure with an 8-ft-wide crest with an el of +10.2 ft lwd. Side slopes were 1V:1.3H, and armor stone weighed 3 tons (minimum) with not less than 50 percent of 5 tons or more.
1986	No records of maintenance to the pier are available, and the present condition is not known.

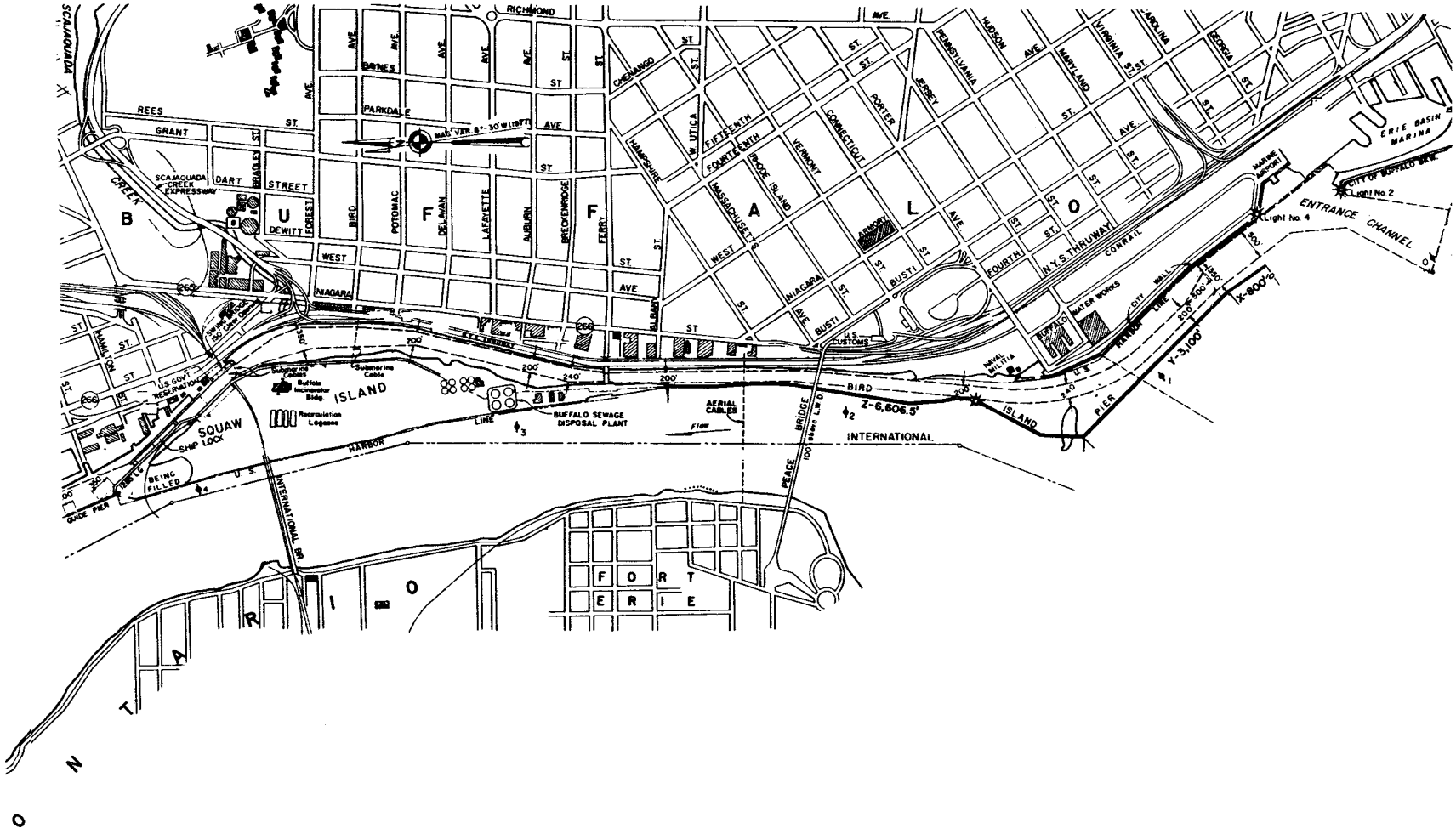
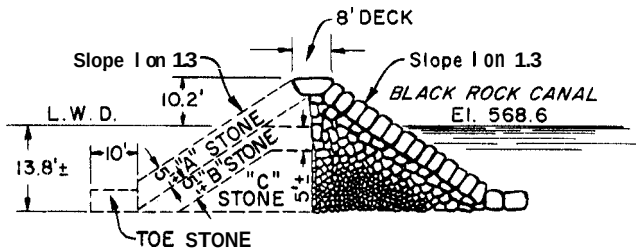
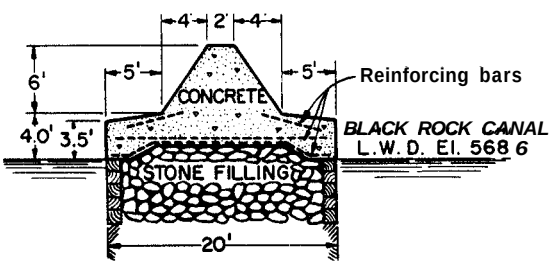


Figure 271. Black Rock Channel, New York

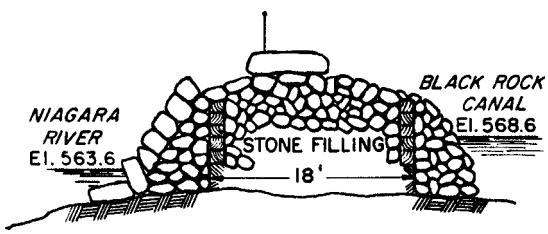


SECTION X
(BUILT 1929 - 1938)

Deck Stone -	Minimum weight 5 tons.
"A" stone	Minimum weight 3 tons, not less than 50% 5 tons or more.
"B" Stone	Minimum weight 150 pounds.
"C" Stone	Not less than 35% 75 pounds or more, not more than 3% less than one pound.
Toe Stone	Minimum weight 7 tons



SECTION Y
BUILT SUB-STRUCTURE 1869-1892
SUPER-STRUCTURE 1928 - 1929



SECTION Z
BUILT 1822 - 1825
(REBUILT 1837 - 1937)

TYPICAL SECTIONS OF BIRD ISLAND PIER

Figure 272. Typical structure cross sections, Black Rock Channel, New York